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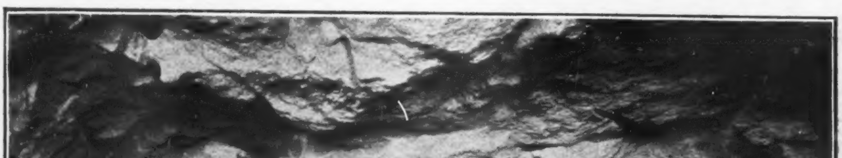
A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. VII. NEW YORK, APRIL, 1902. No. 2.



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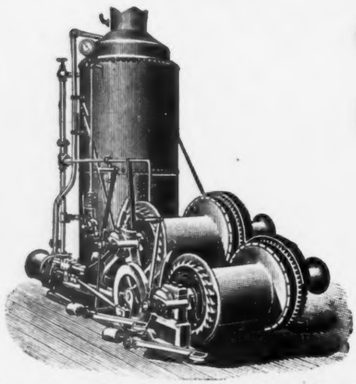

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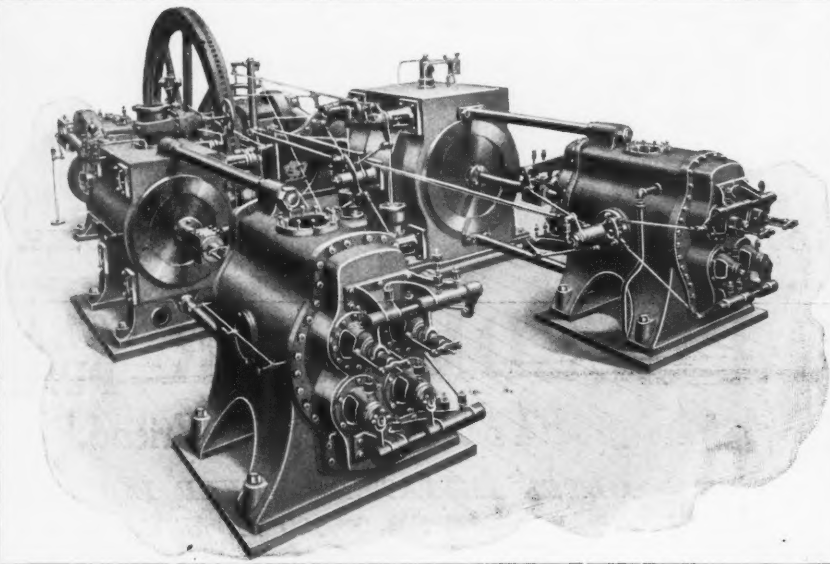

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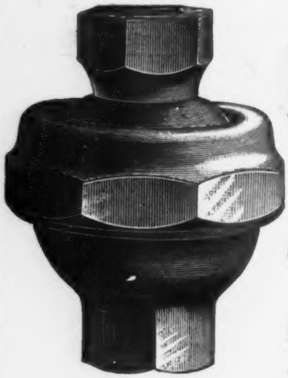

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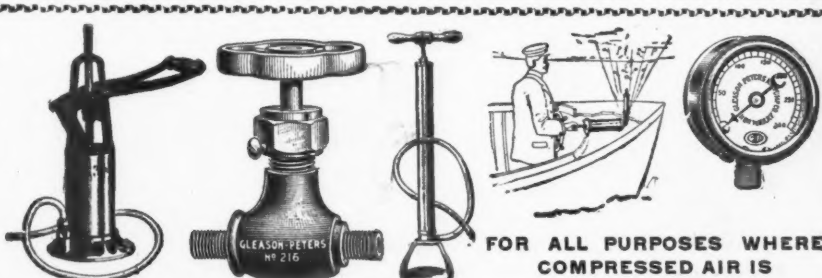

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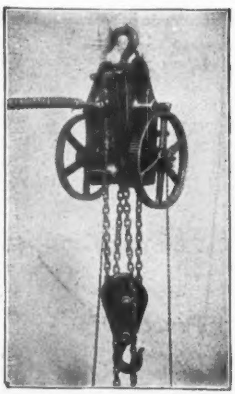

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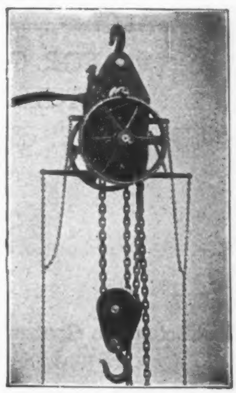

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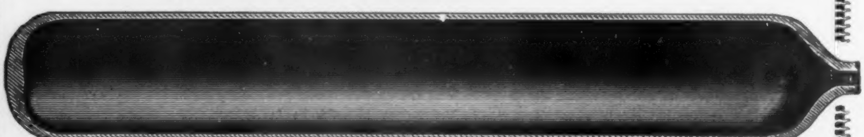

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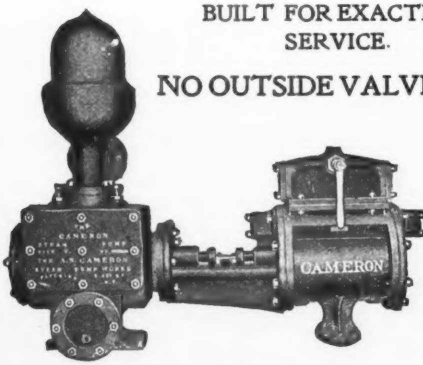

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VOL. VII. APRIL, 1902. NO. 2.

Elsewhere in our present issue we publish a table and some descriptive matter on the yield of air compressors which is largely an abstract of a treatise of mine working recently published in Paris. We publish this table since it is practically the first general comparison of several of the prominent makes of compressors, especially foreign compressors, which has come to our attention. At the same time we must caution our readers against placing too much dependence in the figures, as the conditions of operation are not specified and these have a great deal to do with the showing which any one of the machines would make.

The figures are of interest, however, in that they show to a large degree how nearly alike jet cooled and jacketed cooled compressor cylinders are. Early American practice was identical with foreign made compressors in that this water injector for cooling the air during compression was employed. It is unquestionably true that air compressor practice has developed more rapidly in the United States than elsewhere, certainly if we accept a few isolated cases, such as the compressed air plant in Paris and the air system of one of two of the large mines.

It is also interesting to know that American manufacturers have without exception abandoned the water injector for cooling the air and have adopted the water jacketed cylinder and two or three stage compression with efficient intercoolers between the cylinders. The reasons for this change are not sentimental, but rest on the firm foundation of extensive practical experience.

If a large volume of air is required either a large slow speed engine can be employed or a small high speed compressor. As a general rule, consideration of space has demanded compactness and it has been found easier to obtain a quantity of air by increasing the speed of the compressor. Another limitation in the case of injector cooling is the fact that the compressor to all intents and purposes becomes a species of pump and its operating speed is, therefore, closer to that obtained in pump practice.

Referring to the table this point is nicely brought out. It will be noticed that the foreign compressors, with a few exceptions, have a limiting speed of something less than 75, whereas the American machines operate at from 80 to 150.

We regret that the compiler of this table did not add another column giving the weight of the machine per cu. ft. delivered. In America we can speak with regard to the construction of air compressors with a complete knowledge, because of our experience with both types. Abroad

we are inclined to believe that their knowledge is somewhat bias, as so far as we know, they have never done anything with jacket cooled air compressors and have adhered almost universally to the injector type.

The descriptive matter accompanying this table is, however, of interest since it explains this, we are tempted to say, one side view.

Compressed Air.

An Introduction of the Subject at the Annual General Meeting of the Canadian Mining Institute, by W. L. Saunders, of New York.

In introducing the subject of compressed air before the members of this Institute, I feel that I am addressing those who are not only interested in the subject, but through the discussion which will follow I hope to gain a good deal of practical information. To me compressed air has been a close study and a pleasant pastime for more than twenty years, and yet every time I attempt to climb up on a pedestal and pose as an expert, I see all around me things that I did not know. Though one of the oldest of the sciences, there is really less known about compressed air than about steam, hydraulics, or electricity, and however deeply we may dig into the theories of thermodynamics, we find every now and then a practical mining engineer who shows us by a little experience that the formula which has been guiding us is nothing but a cobweb without substance or strength.

I remember very well my first researches on the subject of compression. After learning what was meant by isothermal compression, it appeared very plain that a serious loss was suffered to take place in the cylinder of an air compressor by attempting to compress without injecting a spray of cold water into the cylinder during the process. All theories and most authorities taught me to advocate the "wet" type of compressor as distinguished from the "dry," and yet it is a fact that at the present time I do not know of a single builder who follows the wet process. It must not be inferred, however, that the importance of cooling during compression was overestimated. We have learned to cool by compressing in stages and have abandoned water injection because of its complications of apparatus, the inevitable destruction of wearing parts, and because it is not advisable to bring air and water together while the air is at a high temperature. The reason for this is that the capacity of air to take up moisture is in direct proportion to its temperature, and even with the most efficient system of spray injection it is difficult to start the compressed air on its journey to the mine at a temperature low enough to produce dryness. During the building of the Washington Aqueduct Tunnel a central air compressing plant was located at the foot of a hill. The transmission pipe leading up the hill to the shafts would at times become practically filled with water, which would be taken up and sent forward like a piston into the workings. It is interesting here to note that this difficulty was overcome by pumping fresh, cold water into the air receivers at the foot of the hill, thus condensing the moisture of compression. Dry stage compression actually gives as a pressure line more nearly the isothermal than was obtained by the injection process. In stage compression there are two or more air cylinders, each surrounded by water jackets. Intercoolers are placed between the cylinders, and in this way the air is alternately compressed and cooled until it is discharged into the receiver. By this process the air is maintained in a dry condition, and as it at no time reaches adiabatic, or the heat maximum of temperature, it is not "burned," but is delivered into the mine in a fresh and healthy condition. Too little importance is sometimes given by engineers to the intercooler. The common or cheap form of intercooler only partially serves the purpose, but the intercooler, which is composed of nests of tubes around which the air circulates, splits up the air into thin layers and as cold water passes through the tube these thin layers are rapidly reduced in temperature; so that with cold water, which I judge is not difficult to obtain in Canada, it is quite possible to obtain air temperatures in the intercoolers considerably lower than was the temperature of the air before it entered the compressor. This is an important

point as affecting both the actual and the volumetric efficiencies of the air compressor. The theoretically perfect compressor is one which draws in air at a temperature of zero or lower and discharges it compressed at normal or outside temperatures. We must always bear in mind that during compression the temperature of the air at any stage depends upon its initial temperature, and that the higher the initial temperature is the higher will be the temperature throughout the process of compression. This is not a theoretical but a practical question, which concerns those who are engaged in the every day practice of air compression. Engine rooms are usually warm and dirty places from which to draw a supply of air for the compressor. Hot air means thin air, and thin air drawn into a compressor means a low volumetric efficiency. The mine owner who pays for an air compressor of a certain size naturally wants to get out of it all the compressed air he can. He should, therefore, see that the compressor draws air from outside the engine room and from the coldest spot on the property. He should also see that his compressor is provided with a thorough system of cooling, because no matter how cold the air may be, when it goes into the compressor, it is sure to warm up by the action of the piston. This warming up process causes the air to expand and to resist the act of compression in degree directly in proportion to the increased temperature, that is, the hotter it is the harder it is to compress the air and the more power is consumed for a given volume. To express this in figures we find that when air is compressed in a single stage machine from atmospheric pressure and 60° Fahrenheit temperature to 80 pounds gauge pressure, the maximum theoretical loss due to increased resistance through heat is about 33 per cent. when represented in foot pounds of work. As a matter of fact no such loss is ever suffered because maximum temperatures are never reached even in single stage compressors; cool metallic parts brought in contact with the air absorb some of this heat, so that we may safely say that a well-designed water-jacketed single-stage compressor suffers a loss of 20 per cent. in foot pounds of work when compared with isothermal or perfect compression, and under the conditions of temperature and pressure stated above. We may therefore say that in compressing air to 80 pounds pressure without compounding, it is possible to lose one-third in power, though we usually lose one-fifth. To illustrate with these figures the importance of compounding, I would state that under the conditions stated a two-stage compound compressor when properly designed would suffer a loss of a fraction over 15 per cent., and in a four-stage machine we are able to get this down to nearly 5 per cent. As some of you may be using air at 100 pounds pressure, you may be interested to know the figures under these conditions. The maximum loss in a one-stage compressor is 38 per cent; this in a two-stage machine may be brought down to a fraction over 17 per cent and in four stages to 8 per cent. Even at 1,000 pounds pressure the heat loss in a four-stage compressor is brought down to 17 per cent. All representing foot pound of work.

The subject of cooling is not complete without a brief statement about after cooling. It is easier to get our ideas about intercooling carried out than it is to get any hearing when we talk about after-cooling. Assuming that you agree with me that air should be cooled before it enters a compressor and that this process of cooling should go on *during* compression, I would also like you to agree that even after we have bottled up the air in the receiver, something might be gained by inflicting it with a further and final cold bath. This is really the last time that the cooling process should be applied, and from this time on we are to turn square about, reverse our treatment and begin to warm up. An aftercooler between the compressor and the receiver or just outside the receiver in the main line, is a good thing because it will serve as a condenser to abstract moisture from the air by bringing its temperature below the dew point. Air at all times contains moisture, the average moisture being about 50 per cent of what is required to produce saturation, and it is safe to say that during our cooling process in the compressor we are not likely to abstract any of this moisture. The only mechanical way as distinguished from the chemical process by which we may get moisture out of air is to lower its temperature, but we must lower it below its initial temperature

to produce any results. Notwithstanding the best systems of jacketing, compounding and intercooling, the compressed air is usually discharged into the receiver at a temperature about double the initial temperature, and as this air cools on its journey to the mine, it is likely to condense moisture on the interior walls of the pipe. In cold weather this freezes and accumulates, sometimes restricting and even stopping the passage of the air. In other cases it condenses its moisture in the ports and passages of the drills and pumps. These troubles can be reduced to a minimum and even overcome entirely by a thorough system of after-cooling, which means nothing more than reducing temperature and abstracting moisture just outside of the engine room.

Before leaving the subject of compression, I would say a word about oil. Air cylinders do not require oil either in quality or quantity like steam cylinders. What is good for the one is bad for the other. A steam cylinder needs an oil of low flashing point, and plenty of it, because the tendency of the wet steam is to wash the oil out of the cylinder. Not so with air, there is no washing tendency and very little oil will last for a long time. This oil should be of the best quality obtainable and of a high flashing point. It should not be a coking oil; that is, when evaporated on a piece of hot metal, it should not leave a carbon deposit. This is a subject which has been very much neglected, and this neglect is responsible for much waste of money and, worse than this, for explosions which destroy property and threaten lives. The actual amount of oil that should be used in an air cylinder is one-quarter that which should be used in a steam cylinder of the same size. I would call this a maximum, for very much less will often suffice, especially where the oil is of the best quality. Too much oil where there is a coking tendency results in choking the valves and ports. A discharge valve might stick through coking, and when stuck it will admit some of the hot compressed air into the cylinder against the receding piston, which on the return stroke is compressed and carried to a temperature beyond the flashing point. Sometimes when discharge valves give trouble, they are cleaned by injecting kerosene. This is a fatal error. Kerosene should never be used in the air cylinder, but, instead of this, fill the oil cup with soap suds, made preferably out of soft soap, and feed this into the cylinder; let the compressor work with soap suds instead of oil for a day each week and no harm is done, care being taken to feed with oil a half hour before stopping, so that the parts may not be subject to rust, which is the only danger from soap suds.

Compressed air has always been, and still is, supreme in mining. As a means of transmission and for surface work it must in many cases give place to electricity and hydraulics, but as an underground power its supremacy is admitted. No power is so safe, none so free from objections in mining work. It aids ventilation and cools the heading. If the conduit pipe is large enough, you will suffer no loss by friction and may convey compressed air several miles from the generating station. In recent years compressed air economies in production, transmission and use have opened up a large field in directions other than mining. All of our large railway systems are now provided with pneumatic appliances in the shops, and many of them use the system for switching. Machine work of all kinds, such as drilling, chipping, riveting, moulding and hoisting, is done by compressed air. The air lift pump for lifting water, salt water and oil from wells occupies a field of much usefulness. The compressed air locomotive has an established place in and about mines, nine of them being in constant operation in the Anaconda Copper Mines in Montana, and several are now at work for the Cambria Steel Company in Pennsylvania. The use of compressed air in bridge and tunnel work has made possible many of these large undertakings. The Blackwall Tunnel under the Thames, in England, is one of the most recent evidences of the utility of compressed air for such work. The stupendous scheme, which has been inaugurated by the Pennsylvania Railroad, to bring its terminal into the heart of New York City is made possible only by the use of compressed air.

In conclusion, it may be interesting to call your attention to a column of "don'ts," which I found in an engineering paper published in far-off New Zealand, and

from which we may all, I think, carry home with us some useful lessons.

Don't install a compressor just about equal in capacity to your present requirements, for when once you have compressed air available its number of uses become legion. Good practice is to provide a compressor at least 50 per cent. greater in capacity than your immediate necessities demand. Duplex compressors are made divisible, permitting the installation and operation of one-half at first and the other half later when the additional capacity is needed.

Don't accept the theoretical capacity of an air compressor stated in the list of the maker, as the equivalent of the actual volume of air needed for your service. Remembering the difference between theory and practice, allow a small deduction for friction, heat, clearance, etc., being unavoidable losses in air compression, before calculating what your actual delivery in compressed air will be.

Don't buy an air compressor because it is cheap. It will prove the most expensive proposition of its size that you have ever encountered. If a water pump fails in its work, you will know it at once; if a steam engine is deficient, its shortcomings are self-evident, but if an air compressor is poorly designed or badly constructed, it may continue in the evil of its ways until the scrap heap claims it for its own, unless, as is more than likely, an absolute breakdown calls attention to its deficiencies, and you learn all too late that the hole it had made in your coal pile, added to the loss of keeping it in repair, would have paid a handsome interest on the additional first cost of a properly designed and properly constructed compressor.

Don't buy a second-hand compressor unless you know it has given satisfaction in work similar to your own, and that its working parts retain their full measure of usefulness without deterioration. An air compressor with valves, pistons, etc., worn out or in bad repair can waste more good power than anything of its size known.

Don't buy a compressor that your neighbor used for operating oil burners because you intend putting in pneumatic tools. For, even if all compressors look alike to you, experience teaches that oil burners operate under 12 pounds pressure, whilst pneumatic tools require 100 pounds, and the oil burner compressor, with unevenly proportioned cylinders, devoid of water jackets, will equal your service as well as a low pressure boiler for heating will run a high-speed engine.

Don't use air brake pumps or direct-acting compressors. Statistics show that their steam consumption is about five times that of a crank and fly-wheel compressor for the same volume and pressure of air delivered.

Don't install a steam-driven compressor if your steam supply is short and plenty of belt power available.

Don't put in a belt-driven compressor if you have plenty of steam and are short of belt power.

Don't draw your intake air to the compressor from a hot engine-room, or from any point where dust is abundant. The volume of air delivered by the compressor increases proportionately as the temperature of the intake air is lowered, and dust or grit entering the compressor clogs the valves, cuts the cylinders, and generally impairs the efficiency.

Don't use any old thing for an air receiver. Compressed air under 100 pounds pressure will leak a horse power through a 1-10 diameter hole in five minutes, and a well-made, strong and tight air receiver is the second essentially important factor if you would realize to the utmost all the advantages which compressed air provides.

Don't connect your air admission and discharge pipes improperly at the receiver. To secure the best results and eliminate moisture from the compressed air, connect your pipe leading from the compressor at the top of the receiver and lead your air pipe to points of consumption from the bottom of the receiver.

Don't have leaky air pipes. Test your piping when it is installed, and at regular intervals thereafter, allowing the full pressure to remain an adequate length of time, and if the gauge indicates leakage locate and remedy it.

Don't install your piping without properly providing for drainage of condensed moisture at regular intervals in the system. The simplest method is to slightly incline the branches leading from the main line and insert drain cocks just before the hose connection is reached.

Yield of Air Compressors.

The comparative table given below (reproduced, with equivalents, added, from the treatise on Mine Working, by M. Kuss and M. L. Fevre, Paris, Fanchon,) sums up the characteristic particulars as to the working and yield of several types of compressor. The figures were obtained under very different conditions of experimentation, so that they are not always intercomparable; but they have, nevertheless, the advantage of stating the question precisely with sufficiently near approximation.

Two perfectly opposite tendencies are now manifesting themselves as to the use of air-compressors in connection with mine working. The first, which is special to Continental Europe and chiefly France, consists in carrying water injection to its utmost extreme by realizing a maximum of isothermic compression and thus obtaining a good yield of the compressor itself, but at the expense of complication, additional expenditure of power for the injection (which may attain from 4 to 5 per cent. the power indicated in the steam cylinder), more difficult maintenance and

	Type of Compressor.		Number of Revolutions per Minute.	Piston Speed per Second. Metres per second.	Feet per second.	Absolute Pressure. kg. per sq. cm.	lb. per sq. in.
One Stage.	Sommeiller		13 to 15	0·55	1 ft. 9 in.	6	85
	Hanarte		27 to 28	0·95	3 ft. 1 in.	6	85
			35 to 40	....	....	6	85
	Dubois-François	old	30 to 50	1 to 1·20	3 ft. 3 in. to 3 ft. 11 in.	5 to 6	71 to 85
		present	50 to 60	1·00	3 ft. 3 in.	6	85
	Sautter-Lemonnier		50	1·25	4 ft.	9	128
	Dujardin	old	34	1·30	4 ft. 3 in.	4·75	66
		new	37	1·42	4 ft. 7 in.	5	71
		present	40	1·53	5 ft.	6	85
	Mailliet		40	1·47	4 ft. 9 in.	6	85
			48	2·24	7 ft. 3 in.	6	85
	Biétrix		64	1·92	6 ft. 3 in.	8	113
	Burckhardt & Weiss.		85	....	....	6	85
			70	1·40	4 ft. 7 in.	6	85
			104	....	....	4	56
	Ingersoll-Sergeant.	A. No. 21	80	2·03	6 ft. 7 in.	6·6	93
		G. No. 23 A	120	1·83	6 ft.	5·2	74
		H. No. 313	150	....	....	5·2	74
Two Stage.	Dubois (Anzin)		52	2·08	6 ft. 9 in.	6	85
	Le Creusot		56	2·33	7 ft. 6 in.	6	85
	Ingersoll-Sergeant.	C-2 No. 229	85	2·59	8 ft. 5 in.	8	113
		AC No. 13 C.	110	....	....	6·6	93
		H. No. 324	150	....	....	6·6	93

more frequent repairs. This method generally dispenses with compression in stages, even for pressures attaining 7 to 8 kilogrammes per square centimetre (mean 106 lbs. per square inch), unless indeed it be desired to produce very large volumes of compressed air.

and loss of mechanical work inherent in water injection are avoided. There is accordingly every advantage, for pressures at all considerable, to resort to compression in stages, which is obtained in as simple a manner as possible.

To judge by the figures given in the above table, it would appear that the two methods do not, generally speaking, afford a very different final result. It is true that injection compressors provided with the most recent improvements yield very remarkable results, which place them far above non-injection compressors as re-

Effective Pressure. kg. per sq. cm.	lb. per sq. in.	Volume Delivered per Minute. cu. m.	cu. ft.	Volumetric Yield.	Capacity of Production.*	Yield of Motor.	Yield of Compressor.	Total Mechanical Yield.	Lost by Heating and Throttling.	Loss Through Accessory Resistances.	Volume (Reduced to Atmospheric Pressure) Delivered per H.P. per Hour. cu. m.	cu. ft.	Actual Useful Effect.
5 =	71	....	...	0 80	25	0·80	0·81	0·65	0·23	0·25	8·0 =	282	....
5 =	71	....	....	0·90	50	0·87	0·85	0·74	0·17	0·14	....	....	....
5 =	71	4·0 =	141	0·90	60	0·81	0·83	0·67	0·21	0·24	9·75=	343	0·31
4 to 5=	56 to 71	....	....	0·87	130	0·83	0·80	0·66	0·25	0·20	8·50=	299	.. .
5 =	71	....	....	0·95	115	....	....	0·79	...	....	9·60=	338	....
8 =	113	2·8 =	98	0·88	87	....	....	0·67	....	....	7·9 =	279	0·27
3·75=	52	4·3 =	151	0·91	62	0·80	0·74	0·59	0·35	0·26	9·9 =	349	0·30
4 =	56	4·60=	162	0·95	70	0·82	0·94	0·77	0·06	0·22	12·6 =	444	0·38
5 =	71	8·60=	303	0·98	78	0·81	0·93	0·75	0·08	0·24	10·9 =	385	0·35
5 =	71	6·8 =	239	0·93	74	0·80	0·91	0·73	0·09	0·26	10·7 =	377	0·34
5 =	71	12·4 =	437	0·93	89	0·91	0·81	0·74	0·23	0·09	10·8 =	381	0·35
7 =	99	2·4 =	84	0·97	124	0·88	0·91	0·80	0·11	0·13	10·3 =	363	0·35
5 =	71	3 =	105	....	....	0·84	0·65	0·55	0·51	0·20	8·8 =	310	0·26
5 =	71	2·4 =	84	0.65	132	0·78	0·67	0·52	0·50	0·28	7·86=	276	0·25
3 =	42	11·5 =	405	0·95	198	0·78	0·84	0·65	0.19	0·29	....	....	....
5·6 =	79	4·7 =	165	0·90	144	....	....	0·62	....	....	8·6 =	303	0·28
4·2 =	59	6·2 =	218	0·90	224	....	....	0·60	....	....	9·5 =	334	0·30
4·2 =	59	3·2 =	112	0·90	267	....	....	0·65	....	. ..	10·0 =	353	0·32
5 =	71	21·8 =	769	0·96	73	0·79	0·85	0·68	0·17	0·26	9.87=	347	0·32
5 =	71	13·6 =	480	0.93	74	0·84	0·91	0·76	0·10	0·19	11·2 =	395	0·38
7 =	99	4·2 =	148	0·90	112	...	....	0·70	....	....	8·8 =	310	0·29
5·6 =	79	3·6 =	126	0·90	146	....	....	0·78	....	....	11·00=	388	0·35
5·6 =	79	2·0 =	70	0·90	186	....	....	0·72	....	....	10·0 =	353	0·33

* Volume delivered per minute at effective pressure divided by cylinder volume.

In America, on the contrary, all introduction of water into the cylinders has been entirely abandoned; and makers content themselves with cooling down the cylinders by external water circulation. Loss is incurred on the yield of the compression proper; but all the complication

gards the useful effect; but this is not the only matter to be considered when a new plant has to be put down. More or less account must be taken of the dimensions, the weight and the cost of the compressor, as also of the difficulties connected with driving maintenance and repairs. The latter may vary greatly and exert great influence on the cost of compressed air, so that a comparative examination should be made of the first cost and current expense incurred in air-compression. Now, American compressors have in their favor a faster running, and consequently a greater power of production, so that the first cost must be less considerable for a given volume of compressed air. On the other hand the current expense of producing a given volume must be higher in their case, although the difference is diminished by simplicity of parts and facility of driving and maintenance.

To only consider the question of yield, or useful effect, it may be said that the most improved types of European compressors currently attain 70 per cent. the same figure as that realized by multi-stage American types; but that of simple compressors rarely attains 62 per cent., corresponding with actual yields of about 32 and 28 per cent., respectively.

In fine (conclude the authors) for large plants intended to last a long time, and in which economy should be sought on the current expense of production rather than on the first cost, injection compressors must decidedly be preferred, while non-injection types are on the other hand to be recommended for small plants not intended for any considerable duration.

J. Walter Pearse.

A New Air and Gas Compressor.

Since the line pressure of all air compressor plants varies continually on account of the variation in work done by the different motors using the air, the discharge of air from the compressor takes place at a correspondingly varying point of the stroke, and unless the discharge valve mechanism is properly designed, power is lost by early or late opening of the valves. Up to the present time no valve other than the poppet discharge valve has met these peculiar requirements in a satisfactory manner. In proof of this it may be stated that nearly all compressors of standard types are fitted with poppet discharge valves, while intake valves are of innumerable designs, automatic, or positively operated.

While, however, the poppet discharge valve adjusts itself perfectly to variation in load, the available space in the cylinder when using this type of valve is not sufficient to insure ample discharge area for high piston speeds without perceptibly increasing the pressure at the point of discharge, causing a loss of power. Its construction also prevents proper water jacketing, which tends to diminish the efficiency of compression.

In the compressor illustrated in Figs. 1, 2 and 3, the chief object of the designer has been a discharge valve that would be automatic in operation, open and close quickly at any part of the stroke and permit of ample discharge area for high piston speeds with minimum clearance loss. By means of the wrist plate mechanism this valve performs the function of an intake valve as well. The same valve opening is used for admission and discharge, thus further reducing the clearance loss and providing maximum cooling surface in the water jacket at the cylinder heads.

Fig. 1 is an elevation of air cylinder and wrist plate mechanism. Fig. 2 is an elevation of air cylinder from the side opposite to Fig. 1. Fig. 3 is a sectional elevation along the axis of the compression cylinder. A and B are small cylinders shown here fitted with plunger pistons connected to the valve stem.

Briefly described, the method of operation is as follows: At the beginning of the compression stroke the valve is positively closed by means of the wrist plate, and remains closed until the cylinder pressure slightly exceeds the receiver pressure, when it is opened wide by the slight excess of air pressure. The valve remains open to discharge until the piston has traveled to the end of its stroke or expelled all the air from the cylinder. At this point the difference in pressure between receiver and atmosphere, acting on the two smaller cylinders A and B, closes the valve to discharge and rotates it further to its intake position, where it remains until the end of the intake stroke. It is then quickly closed again by the wrist

plate before compression begins. A communicates with the air receiver; B communicates with the inside of the compression cylinder by means of the opening C

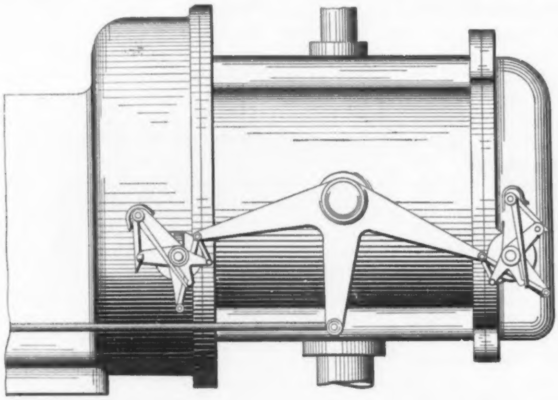


FIG. 1—ELEVATION OF AIR CYLINDER AND WRIST-PLATE MECHANISM.

in Fig. 3. During the intake stroke the plunger pistons of A and B are in the position shown at the right in Fig. 2 (receiver pressure in A and atmospheric or

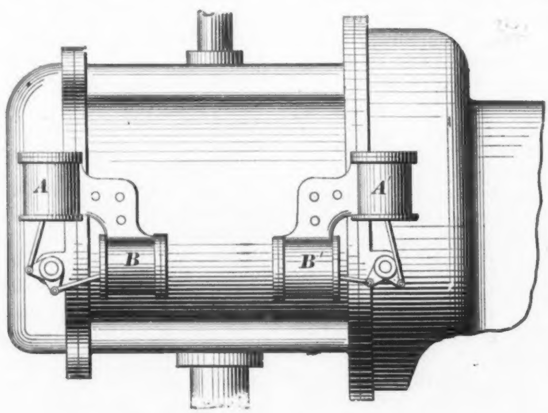


FIG. 2.—ELEVATION OF AIR CYLINDER AND VALVE-OPERATING DEVICE.

intercooler pressure in B). The valve is shown open at the left side in Fig. 3 for corresponding position.

At the beginning of compression stroke the plunger pistons of A and B are moved just enough to close the valve. The corresponding position of the valve is seen on the right hand side of Fig. 3. As soon as the pressure in the compression cylinder (communicating through to the small cylinder B) is slightly in excess of the receiver pressure, it acts on piston of B so that the pistons of A and B balance each other as shown on the left side of Fig. 2. This instantly opens the valve to discharge, and it remains wide open until

the piston has passed completely over the opening C. At this instant the air in the small cylinder B expands to atmospheric pressure through the opening C, causing the plunger of A to drive back the plunger of B very rapidly and noiselessly, B acting as a dash pot. The valve now remains open for the entire intake stroke and is again closed positively at the beginning of the next stroke. The compressor is the invention of F. C. Weber, Park Building, Pittsburg.—*The Iron Trade Review.*

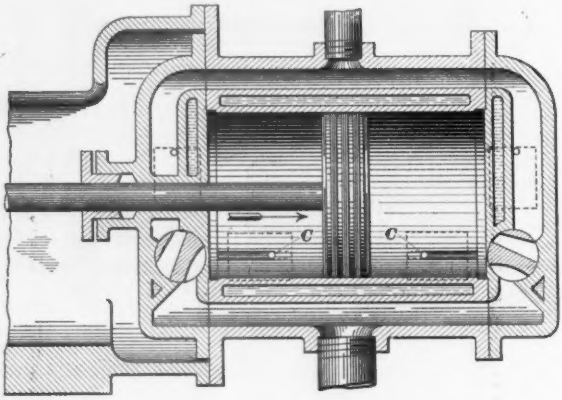


FIG. 3.—LONGITUDINAL SECTION THROUGH CENTER OF COMPRESSION CYLINDER.

The Distribution of Power in Mines.

THE PRINCIPLES RELATING TO THE LOSSES AND ECONOMIES IN ITS TRANSMISSION AND USE.

The writer proposes to discuss the whole question of the distribution of power in and about mines, and also to discuss the question which is closely allied to that of power distribution, viz., the distribution of air in mines for ventilating purposes.

There are several methods by means of which the power that is required for performing the different operations about a mine may be delivered at the points where it is used. There is the oldest method of all, except that of manual labor, that of the horse. There are the methods by which the energy of falling water is made use of, and again the method by which the incompressibility of water is made use of, both of these having a limited application. There are the methods by which the friction of ropes, and their resistance to rupture are used. There is the method still employed in many mines, and in nearly all for a certain portion of the work, that on the surface, the direct delivery of steam at the point where the work has to be done. And there are the two great rivals for the favor of mining engineers at present, the energy delivered to atmospheric air at the surface by compression, and used by expansion where the work is done; and that of electricity generated by the application of steam power to a dynamo, the electricity being caused to drive electric motors at the points required.

All of these have their advocates. Necessarily the maker of ropes is a keen advocate of the utility of rope transmission; he could not live if he were not; and the makers of compressed air apparatus, as well as those of electrical apparatus, have each an unbounded appreciation of the method of distribution in which their own apparatus figures, and each and all are prepared to give any number of reasons why the others are of very little use in every case, except those which the par-

ticular apparatus of the particular advocate cannot deal with. Perhaps the makers who are the least enthusiastic about their apparatus, so far as mines are concerned, in the United Kingdom, are electrical engineers. The advance of electricity has been so rapid during the last ten years, and they have got so to look upon electricity as far and away superior to anything else, that it is looked upon as a foregone conclusion with them that electrical will be *the* apparatus, and that there is an end of the matter. Possibly these gentlemen may have a rude awakening in the near future. It will not do them any harm. Swelled head, which many of them are suffering from, is a troublesome complaint, but the medicine, though unpleasant, is otherwise harmless, and there are signs that they are in for a dose of the medicine right now. The rival methods of doing things, gas, oil, compressed air, water, etc., have completely aroused themselves, and the result, in several portions of the field, is somewhat startling.

There is one very striking fact in connection with the different methods of distributing energy about a mine, or anywhere else, viz., that the same principles underlie the whole of them, the same losses, when reduced to their common denominator, are present with all of them, viz., the loss of heat, which has to be made up in the furnace of the boiler, or in other ways; and the same rules apply, with the exception of here and there, for efficient distribution, for distribution with small loss, or at small charge. The above statement may appear startling at first sight, and it may appear to be stretching matters to say that the losses are all in heat, yet this is the actual fact, and it will be seen that though the form of the loss may be disguised in different ways, the loss comes back to heat, usually to the furnace of the boiler, and in the majority of cases it is not difficult to trace the connection between the loss as it appears and the heat loss it actually represents. In nearly every case it will be found that it is necessary to generate heat in the initial process required for the particular method of transmission, and that while it is to the distinct advantage of the efficiency of the transmission that this heat shall be dissipated, such dissipation, and even the generation of the required heat, represent losses that have to be made up by the initial generator, the steam boiler, in some form or other. Also it will be found that the methods of reducing the initial losses by the generation and dissipation of heat are the same in nearly all the methods that have been employed about mines. It will also be found that it is necessary, in many instances, to generate heat, in the process of converting the power delivered at the point of consumption into the form in which it is required to be used, that this conversion could not take place, nor the apparatus be worked, unless this heat was generated, that again it is best, for the efficiency of the distribution, and often for the working of the machine to which the power is delivered, that this heat shall be dissipated, and that again the dissipation of the heat means loss of energy, which has to be made up in the initial generator, the boiler furnace.

In all systems of power distribution there are two important matters to be considered which are nearly always in antagonism. The cost of the installation, and its efficiency. The cost of the apparatus rules the charge that has to appear in the books for interest and depreciation. The efficiency means really the cost of running, and the mine manager often has considerable difficulty in judging to which side he shall lean, in laying down his plant for power distribution. In nearly every case, for instance, with the initial generator, size means efficiency in the double sense that the repairs bill is less and that there are smaller losses by heat, or the equivalent, losses in other forms which are convertible into heat; but size also means high cost, large interest, and it is quite possible to have an apparatus too efficient, in the sense that it costs too much money, and that the increased efficiency over that of an apparatus slightly lower in the scale of efficiency, may be more than counterbalanced by the increased interest on capital; and it may be absolutely necessary to add a substantial amount for renewal, as some apparatus are moving on at such a rapid rate that the best of to-day is out of date, and will place the user at considerable disadvantage seven or eight years hence. And this contest between first cost and working cost runs all through every part of every installation that is designed for the distribution of power about mines. In all cases

there must be some method of conducting the power to the apparatus it is to work. This conductor in all cases uses heat, it has a life that is more or less limited, but the life and the heat wasted are in nearly all cases less as the size is increased: again size means first cost, with interest and depreciation. And the same remarks apply to the method of conversion of the power at the point of consumption. With certain exceptions, size spells economy in one sense, though it brings increased charges in the other. Again in all cases of transmission, or distribution of power, the higher the pressure, or as it might be written for certain cases, the higher the speed (higher pressure gives higher speed under given conditions), the more economical does the system of distribution become. Gas engineers have discovered this, and have devised high-pressure Welsbach burners which give a light that compares, for outdoor lighting, not unfavorably with the arc light itself. Compressed air engineers have also discovered this a good many years ago, though the discovery has practically laid dormant in the United Kingdom. Engine builders have discovered the same thing, and where we used to look upon 300 feet a minute as a good standard speed for engines, now 600 feet is a very common speed, and with the small engines used for motor cars, in which the fuel is consumed in the cylinder of the engine itself, the piston speed is often as much as 1,550 feet a minute, and the engines work well. Again, steam pressures have increased from the 30 lb. that was so common at collieries 20 years since, and that may be seen now in some collieries, or shall we say, from the first steamer with a boiler pressure of 5 lb. per square inch up to, in the modern "Ocean Tramp," 250 lb. At collieries in the United Kingdom there are few cases where more than 80 lb. is used even yet, though some have ventured as far as 150 lb. Air compression still stands at 50 lb. or thereabouts, and electricity remains at the figure at which it was originally started, 500 to 550 volts, and is in many cases much less in this country. For economy in all the methods of distribution employed, and if British collieries are to hold their own with American and Continental, higher pressure must be used all along the line, and it is not too much to say that the system of distribution which can arrange to make use of the higher pressures will be the most economical, other things being the same.

But high pressures and high speeds have a good deal against them. In nearly all cases, increased pressure means increased waste of heat, merely on account of the increased pressure, or the increased speed. A rope traveling at a high speed creates more friction than one at a lower speed, and so does a piston running at a high speed. Yet high speeds are used in steam engines, and particularly with motor car engines, with success and economy, the heat generated being carried away by the lubrication, and the economy resulting from the fact that the heat wasted costs less to produce under the present conditions than it would have under the old conditions, and to such an extent that an actual saving has resulted. The economy of the high speed or pressure more than balances the waste arising from its use. High pressures in steam bring awkward problems in their train, owing to the increased pressure being accompanied by increased temperature: also high pressures tend to force themselves through joints and openings much more readily than low pressures, and this applies equally to compressed air and to electricity, while the latter has the disadvantage that high pressures are dangerous to life. Yet it appears that high pressures must be used if economy is to result, and the only question must be, how is it to be done.

The advantage of using steam at high pressure is very strikingly seen, when it is remembered that one-tenth of a cylinder full of steam at 200 lb. initial pressure will do the same work in a given engine as three-quarters of a cylinder full with 70 lb. boiler pressure, while a tenth of a cylinder full of steam at 80 lb. will do more work than nine-tenths of the same cylinder full at 25 lb. The heat absorbed in producing the steam at 25 lb. pressure is 1,186 British thermal heat units per pound of steam generated, while that absorbed in producing the steam at 70 lb. pressure is 1,205 British thermal heat units per pound of steam, and that absorbed in producing the steam at 200 lb. pressure is only 1,230 British thermal heat units per pound of steam. Or, in other words, the steam at 25 lb. pressure costs 47 units per pound of pressure per pound of steam: the steam at 70 lb., 15 units per pound

of pressure and steam; and the steam at 200 lb. costs only 6 units per pound of pressure and steam. So that where the steam has cost so much less to produce, it may happen to be economy to waste a larger portion of the energy delivered to a given apparatus than where the steam costs more to produce. It will be remembered that the British thermal unit is that quantity of heat that will raise 1 lb. of water 1 degree, Fahrenheit. This may be connected directly with the boiler furnace by taking the number of pounds of water that any particular fuel will evaporate. If we take the figure that is usually adopted as a standard, viz., 8 lb. of water per pound of fuel, at and from 212 degrees, Fahrenheit, this means that for every pound of coal used to raise steam to 200 lb. pressure, 7.3 lb. of steam approximately are produced, and for the 70 lb. steam, 7.4 lb., and the 25 lb. steam, 7.55 lb., while the 200 lb. steam has over seven times the value for power purposes of that at 70 lb. and more than 60 times the value of that at 25 lb. pressure.—SYDNEY F. WALKER, in *Mines and Minerals.*

Underground Compressed Air.

MINE PLANT—THE APPLICATION OF COMPRESSED AIR TO ROCK DRILLS, PUMPS, HOISTING ENGINES AND COAL CUTTERS.

For mining and tunnel operations the transmission of power by compressed air as compared with steam, is especially valuable and convenient for three reasons: *First,* its loss in transmission through pipes is small; *second,* the troublesome question of the disposal of exhaust steam underground is avoided; *third,* the exhaust air is of direct assistance in ventilating the working places of the mine. In large mines, where it may be necessary to carry steam thousands of feet, down shafts and through lateral workings, the disadvantages attending its use become very apparent; the amount of condensation is serious, even when the piping is provided with good non-conducting covering, and the working efficiency falls to an abnormally small figure.

Without reviewing here the relative merits of electricity, as a competitor of compressed air, a salient point may be noted. For work of an intermittent character, such as the driving of rock-drills, underground hoists and haulage motors, compressed air is in some respects superior to all other forms of power transmission; because, aside from leakage in piping—which is largely preventable—there is but little expenditure of power, or loss of work, when the motors are not in actual operation. When no air is being used, though the compressor may continue running for a time, the power is stored up by the increase of pressure in the receiver and air mains.

While recognizing these advantages, it should be borne in mind that, although the loss attending the conveyance of compressed air in properly proportioned pipes may be made very small, still, owing to the faulty design and operation of plant as ordinarily installed, the net efficiency of the system—including compressor and motor—is often far from satisfactory. Besides the mechanical losses inherent in every conversion of energy from one form to another, a series of unavoidable thermodynamic losses take place, both in the compression and utilization of the air. In the present article, however, it is not the intention to discuss this phase of the subject, but to consider some of the features of compressed air machines as commonly employed for underground service.

Compressed Air Drills.—Though it is a well-known fact that compressed air drills are uneconomical machines in their consumption of power, it appears to be practically impossible to put the matter in the shape of figures. The actual useful work —employing this term in its ordinary mechanical sense—done by any machine drill in making a hole of given depth and diameter in a rock of given hardness, toughness, and general physical character, can not be determined absolutely. All that is really known is that the drill requires a certain volume of air per minute, which has been furnished by the expenditure of a certain average horsepower at the compressor.

Mechanical efficiency, pure and simple, is the basis upon which machines in general are compared, but in the case of compressed air drills, mechanical efficiency is not the only question at issue, nor is it the most important. Efficiency of operation is subordinate to the attainment of strength

and simplicity of construction, portability, durability, ease and readiness with which repairs may be made, and capacity for work in terms of number of feet of hole drilled. The strong point of compressed air drills is their convenience of application in the special field of work for which they are adapted. In possessing a cylinder, piston and valves, the drill resembles a steam engine, but there the likeness ceases. There can be no flywheel, or other means of storing up and equalizing the power, and the whole service demanded from the drill is peculiar and totally different from that performed by the steam engine.

The low theoretical efficiency of the air drill is due mainly to the fact that the air is admitted to the cylinder practically throughout the full stroke. As a consequence the valve motion bears a strong resemblance to that of many of the simple pumps. Expansive working to any extent is not practicable for rock drills, both because of the undesirability of introducing complexity of mechanism in machines subjected necessarily to rough usage, and because of the difficulty of adapting a cut-off gear to the variable length of stroke required. Owing to the nature of its work, the drill cannot be kept always at full stroke. While in operation it is often necessary to feed the machine so far forward that the actual length of stroke may not be much greater than one inch, and the valve motion must still be capable of reversing promptly. A sharp, quick reversal of the stroke is absolutely essential. Nearly all the useful work is done on the forward stroke, in striking the blow. If the valve be thrown too soon, the stroke of the piston will be shortened, and the effect of the blow reduced; if too late, the piston may strike the cylinder head. The speed of the drill must be great—say 350 to 400 strokes per minute—and, as a nearly uncushioned blow should be delivered, the exhaust on the forward stroke must be free. On the back stroke, on the contrary, the exhaust must be so adjusted that the piston will be cushioned to avoid unnecessary shock and injury, only enough power being developed on this stroke to overcome the resistance due to the weight of the moving parts, and the frequent tendency of the bit to stick fast in the hole.

For these reasons, it is impracticable with machine drills to attain the economy resulting in other air motors from using the air expansively. Incidentally, the use of air at full stroke is of some advantage, because, in exhausting at high pressure, the exhaust air issues from the port at a high velocity, and its force, combined with the development of some heat from friction, in a measure prevents any troublesome accumulation of ice. The ice is confined, at least, to the exterior portion of the port, whence it is easily removed.

The volume of free air (that is, air at atmospheric pressure) required to operate a machine drill depends upon the gauge pressure, and the size of the cylinder. For drills of different sizes, the volume of air used varies approximately with the squares of the diameters of their cylinders. In making estimates of the quantity of air consumed by a number of drills of different sizes, all can be reduced to terms of one particular size. The 3-inch drill is commonly taken as the standard. At a pressure of 75 pounds a single 3-inch drill will use from, say, 110 to 125 cubic feet of free air per minute, according to the type and condition of the machine, provided it is not materially worn, or otherwise out of repair. But, when several drills are operated from the same main, the average consumption is taken at a lower figure; for the reason that the larger the number of drills the greater is the probability that all will not be running at the same time. Thus, for five 3-inch drills, the total average consumption of free air, at 75 pounds gauge pressure, would be about 450 cubic feet, or 90 cubic feet each, and for ten drills, say, 800 cubic feet, or only 80 cubic feet each.

In 1898, an elaborate test was made at the Rose Deep Mine, South Africa, by Mr. L. I. Seymour. The average number of drills (Ingersoll-Sergeant), of several different sizes, in operation during a six-hour run, was calculated to be equivalent to thirty and nine-tenths 3¼-inch drills. Average air pressure, 69.83 pounds. Average volume of free air used per drill per minute, 81.08 cubic feet. Horsepower developed per drill in the steam cylinders of the compressor, 12.72. It was estimated, however, that the work done during the six-hour test was about equal to that usually accomplished in eight hours of regular work, the time lost in delays due to shifting and setting up the machines being reduced, so that the actual average

horsepower per drill, under normal conditions, would probably be $12.72 \times 6/8 = 9.54$. The air piping in this case was known to be remarkably free from leaks. It may be added that the average duty per drill was 4 feet 5 11/16 inches of hole per hour (diameter of the hole not stated). Reducing the above figures from terms of the thirty 3¼-inch to the standard 3-inch size of drill, the consumption of air would be

$$\frac{9}{10.56}$$

of 81.08 cubic feet, or about 70 cubic feet per minute. This agrees quite closely with the rate of air consumption usually assigned in estimates for the number of drills in question.

The average consumption of air per drill is less for work in soft rock than in hard, because the holes are drilled faster, and more time proportionately is occupied in shifting the machines from hole to hole. In very hard rock the drills are kept running with but few intermissions, and it is advisable to provide a greater compressor capacity than is usually given in the tables of the makers. As a partial offset, however, more time is lost in changing bits when drilling in hard rock, because they are dulled more quickly and must be replaced at shorter intervals. In general, the time actually occupied in drilling may vary between four hours and six hours out of a shift of eight hours. The compressor, in any case, should be of ample size, so as to be able to run at a moderate speed and avoid excessive heating in the cylinder and receiver. When old drills are used, whose valves, cylinders and pistons are worn and permit leakage, the consumption of air is greater than for new machines. Leaky valves may be detected by the character of the exhaust. When the valve is in good order the exhaust takes place in sharp, distinct puffs; when leaky the exhaust is practically continuous.

In operating a compressed air plant at an elevation above sea level, allowance must be made for the decreased capacity of the compressor. It will, of course, be understood, for the same pressure, the volume of compressed air used per drill is constant for all altitudes; but to furnish this air, when working at an altitude above the sea, a larger compressor capacity is required, because a greater number of cubic feet of the more rarified air must be compressed. A series of experiments, made not long ago by Messrs. J. E. Bell and L. L. Summers, shows that the volume of free air used per shift of eight hours for a 3-inch drill is as follows, the gauge pressure being 100 pounds:

At sea level..........25,000 to 42,000 cu. ft
At 5,000 ft. elevation...30,000 to 49,000 cu. ft
At 10,000 ft. elevation.35,000 to 60,000 cu. ft

Aside from questions of the size and type of machine drills, the speed of advance, measured in linear feet of hole, varies greatly in rocks of different characters. Under favorable conditions, in underground work, average duties of 60 to 70 feet of hole per ten hours may be attained, occasionally even higher; in harder rock, from 40 to 50 feet. For short runs considerably better records than these have been made.

Operating Pumps by Compressed Air.—The advantages attainable, under some circumstances, by using compressed air instead of steam for driving underground pumps, are often nullified by an improper choice of the pump itself. The pumps commonly employed in mines are ordinary simple steam pumps (often old ones), and little or no attention is given to the important matters of the relative dimensions of the steam and water cylinders and the proportioning of the air pressure to the cylinders and to the head under which the pump is to work. Unless the air be previously reheated the results obtained from using compressed air in such pumps are no better, and may be even worse, than those obtained from steam. As with steam, the air is usually admitted nearly throughout full stroke, and a cylinder full of air, approximately at gauge pressure, is exhausted at each stroke. The very small cut-off given to these pumps is intended mainly to allow the constant pressure in the water end to overcome the inertia of the moving parts, as the piston reaches the end of its stroke. Again, when several pumps are operated from the same pipe line, as is generally the case in mines, it is customary to work all under the same air pressure, even though the conditions be dissimilar. Where there are a number of levels the pumps are distributed in the mine according to various requirements, as to height of lift and quantity of water. The lowest pump may be working under a head of 1,000 feet or more, others under a head of only 100 or 200 feet. Each is

supposed to be proportioned properly for the volume of water to be raised, so far as the water end of the pump is concerned, but the power end is often badly designed and out of proportion. The tendency is, of course, to err on the side of furnishing too much power. The steam (or air) cylinder may be of such a size as to require a pressure of only 30 or 40 pounds per square inch, while the pipe-line pressure may be 70 or 80 pounds, as is usual with mine compressor plants. So it often happens that the deepest pump in the mine is the only one operating under a proper pressure. The cylinders of the others, though required to do less work, are filled with air nearly at full pressure when the exhaust takes place, even if running under partial throttle. If the pump be of the duplex pattern, with inter-dependent valve motion, the conditions at times are even worse, because one cylinder may be overfilled with air, while waiting for the piston of the other to finish its stroke and reverse the valve.

It is apparent that, with the common direct-acting simple pumps, uneconomical working is inevitable. The trouble is twofold; the air is used without expansion, and often at a much higher initial pressure than is necessary.

The second point will be dealt with briefly in another article, where it will be shown that the air pressure can be diminished by inserting a reducing valve in the pipe line near the pump. By this device such a volume of air is allowed to pass as will maintain a certain difference in pressure between the air in the main and that at the pump. Not only does this cause a deposition of part of the moisture, which may be drawn off, and so prevent serious freezing at the exhaust ports, but in adjusting the pressure to the requirements of the pump, a reasonable degree of economy in the consumption of air is brought about. After passing the reducing valve the air is led into an auxiliary receiver before reaching the pump.

Pumps Using Compressed Air Expansively.—Reference may now be made to the first point mentioned above. The considerations as to initial cost and the scale of work, which so largely govern the selection of steam pumps, are operative also in the case of those driven by compressed air. For small plants, ordinary simple or duplex pumps, working non-expansively, are the rule, because of the greater cost and complication of the mechanism of those possessing expansion gear. This type of pump, however, whether operated by steam or air, is far from being satisfactory, and the subject—at least as regards mining practice—merits the careful attention of mechanical engineers. With pumps of any considerable size, expansive working in some form should be introduced. It seems probable that where compressed air is used the non-compound fly-wheel pump, with air and water cylinders set tandem, may be most easily and cheaply installed. This arrangement permits a ratio of cut-off which adds materially to the efficiency, and makes possible a simple and strong construction, well adapted for the somewhat rough usage often received by underground machinery.

In aiming to attain the greater economy resulting from expansive working, means to prevent freezing of the moisture in the air must be adopted. A large part of the loss of heat takes place inside of the cylinder, instead of outside at the mouth of the exhaust port, as in working at full pressure. The same total fall of temperature occurs in either case, whether working at full stroke or with cut-off; but, when the air expands within the cylinder, the force of the exhaust is diminished because of the reduction of pressure at the end of the stroke, and the inner portions of the ports are the more liable to be choked with ice. Hence it follows that the ordinary methods for preventing freezing in the cylinders of pumps which take air throughout full stroke are ineffectual for pumps or other air engines working expansively. To accomplish this, as well as to use the air with a greater degree of economy, the air should be reheated before it enters the cylinder, or heat applied externally at least to the cylinder itself. Without detailing here the various kinds of reheaters, it may be stated that they consist in general of a system or coil of piping, forming in effect a part of the air main, and which is inclosed in a small furnace, or heated by other convenient means. Heat applied in this way produces an additional volume of air at a much lower cost than if it were produced in the compressor.

In connection with reheating an advantage may be obtained by injecting into the reheater coils a small quantity of water.

The water is converted into steam, and on giving up its latent heat in the water cylinder prevents the production of very low temperatures, even when a high ratio of expansion is employed. If it be impractical to use a reheater, underground heat may be applied to the outside of the cylinder; for example, by enveloping it with spiral hot water or hot air pipes, or by injecting into it a spray of warm water. Better results are obtainable by injecting steam instead of water into the air cylinder. Not only is a more intimate mixture produced between the moisture and the air, but in condensing, the latent heat of the steam is given up. Each pound of water ejected at 212° F. will give up 180 thermal units, in cooling down to 32 degrees. But, with the steam at the same initial temperature, each pound in condensing gives up 966 thermal units, besides the 180 units produced by cooling subsequently to 32 degrees.

Sometimes the air cylinders of small compressed air pumps are warmed by lamps or torches, but this is objectionable, as the machines become extremely dirty. Some benefit may be derived by leading a jet of water from the pump-column pipe into the air pipe before it reaches the cylinder. Only a small quantity is required to prevent an excessive drop in the temperature of the exhaust. Merely to prevent freezing, the plan of carrying a very small steam jet over the exhaust port has been adopted; but it is obvious that this could be done only when steam is used nearby for some other purpose. Moreover, the heat of the steam so applied is utilized much less perfectly than if used in a jacket around the cylinder.

If compressed air be used in a compound pump reheating is essential, both as a matter of economy, and because of the ratio of expansion (and consequent production of cold) is much greater than that due to the employment of a cut-off in a single cylinder. It would be practically out of the question to allow the cold, partially expanded air, as exhausted from the high-pressure cylinder to pass directly into the low-pressure cylinder. A second reheating, therefore, should be applied to the air after it has done its work in the high-pressure cylinder, and before it enters the low-pressure cylinder. The temperature of the air, after expansion in the first cylinder, is thus raised sufficiently to prevent the temperature of exhaust from the second cylinder from falling too far below the freezing point. Under circumstances where the use of a reheater requiring the burning of fuel is not convenient, an ordinary boiler feedwater heater has been successfully employed.

Following is the description of a plant in the Gwin Mine, Calaveras County, Cal., as installed by Edward A. Rix, of San Francisco. A Worthington compound pump, having a capacity of 200 gallons per minute, was installed on the 600-foot level of the mine. In connection with the suction pipe was placed a 300 horsepower Wainright heater, containing a number of corrugated copper tubes. The water in the sump, at a temperature of 60° to 70° F., passes through the heater tubes on its way to the pump suction valves. The air, after being exhausted from the high-pressure cylinder, at a pressure of 35 pounds, passes into the shell of the heater and through the spaces between the tubes. In this way the temperature of the air is raised practically to that of the water, and, after expanding again in the low-pressure cylinder, is exhausted without freezing. It is interesting to note that as the sump water was at first foul the inside of the heater tubes frequently became coated, and their conductivity was so much reduced that the pump would freeze up. After clearing the tubes the pump operated as freely as before. Still better results would be obtained from such an installation by water-jacketing both high and low-pressure cylinders, the jackets being connected with the pump column by a small pipe.

Compressed Air Hoisting Engines.—Hoists for underground work are almost always of small size. Occasionally it may be required to erect a hoisting plant at a shaft sunk from a tunnel, where, on account of the distance from the boilers and the injurious effect upon the ventilation of the mine, steam could not well be employed. Such a hoist could be operated by electricity, gasoline or compressed air, and might be of considerable size and power. Compressed air is also applied sometimes in collieries for operating stationary haulage engines for underground systems of transportation. It may be necessary to place these engines a long distance from the bottom of the shaft, where

the presence of explosive gas makes it expedient to avoid all possible risk from sparks, either originating at the commutators of electric motors, or caused by the rupture of conductors. Such service for compressed air is more common in Europe than in this country. Up to the present time, however, the principal application of compressed air hoists is for more or less temporary work, such as the deepening of shafts, sinking winzes from one level to another, and the handling of heavy timber for stopes, raises, etc. For work of this character small, portable, self-contained air hoists are employed on account of their convenience, the question of economy being entirely subordinate. As their operation is intermittent, these hoists are usually designed to take air throughout nearly the full stroke; or at least with no more expansion than that due to the lap and lead of the slide valves. At best only a very limited cut-off could be applied, because hoisting engines are denied the equalizing effect of flywheels. Except for small portable hoists reheaters would be of advantage, although, on account of the intermittent work the cylinders in some degree tend to recover normal temperature between hoists.

Coal Cutters Operated by Compressed Air.—Coal-mining machines, or coal cutters, are employed in the actual mining of the coal. They were first introduced about 45 years ago, but were not successful for some years. The great difficulty with which the early inventors had to contend was the lack of a suitable form of power for driving the machines. The transmission of power by compressed air or electricity had not yet come into general use, and steam power is, of course, out of the question for portable machines employed in the working places of mines. Compressed air was probably first applied successfully to coal cutters in 1877; electricity not until 1889.

For the present brief description coal cutters operated by compressed air may be divided into two classes:

First, those in which the driving engine consists of a pair of small horizontal cylinders, coupled at 90 degrees to a crankshaft. The power is transmitted by gearing to a rotary horizontal disk, or bar, or chain, carrying a series of cutting bits, by which a groove or undercut is made in the coal. For the bar and chain cutters, the cylinders are usually from 5 in. × 5½ in. to 6½ in. × 5 in., running at, say, 200 revolutions per minute; for disk cutters, cylinders as large as 9 in. × 8 in., 7¾ in. × 10 in., and 9 in. × 10 in. are used, running at 150 revolutions and geared down to 20 or 30 revolutions for the cutter disk.

Second, machines of the percussion or reciprocating type. These are often called "pick machines," and are similar in general construction to percussion rock drills, the cutting bit being attached to the piston rod of the cylinder.

Standing in a class by itself is the Stanley heading machine, intended specially for driving colliery gangways. It cuts a cylindrical heading. This useful machine is driven by a pair of vertical compressed air cylinders, the exhaust of which assists in ventilating the heading, and carries out the dust. The central horizontal shaft carries a pair of arms (sometimes a flat cone), upon which are mounted a series of cutting bits.

For operating machines of the first mentioned forms, it may hardly be doubted that electric power is preferable to compressed air, both in point of economy and convenience. Compressed air cannot well be used expansively in such portable engines, for reasons already given, and as the machines are moved from place to place, the air piping cannot be as readily shifted and extended as electric wires. As a result, most of the mining machines of this type in the United States are driven by electricity. In Great Britain, compressed air has long been in general use for disk and bar cutters, though electric machines are now coming into favor. When driven by compressed air these cutters are designed for a low air pressure, say 40 pounds.

Up to the present time all of the successful reciprocating or pick machines have been operated by compressed air. Several different makes are widely used in this country, and have found their way also to Europe. The best known pick machines are the Harrison, Sullivan and Ingersoll-Sergeant. The Yoch and the H. & H. picks have also been used to some extent. These machines are mounted on a pair of wheels, by which they are easily moved from place to place and set in position for work. They are intended not

only for horizontal undercutting in breast or room work, but also for "shearing;" that is, making vertical cut on one or both sides, for driving gangways.

In constructive details pick machines differ greatly. In the latest form of the Harrison pick a pair of short slide valves are operated by a small rotary engine, mounted on the main cylinder. At a speed of 200 strokes, and an air pressure of 70 pounds, about 14 cu. ft. of compressed air, or, say, 80 cu. ft. of free air, per minute are consumed, not including preventable leakage from pipes. The construction of the Ingersoll-Sergeant and Sullivan pick machines resembles that of the ordinary rock drill, though the cylinders are larger and heavier. They are provided with a common spool or piston valve, which operates a slide valve controlling the main ports. The valve motion is so arranged that, if the piston overruns its stroke air is compressed in the forward end of the cylinder and forms a cushion. At 200 strokes and an air pressure of 75 pounds they use about 90 cu. ft. of free air per minute. Their rate of work is approximately the same as that of the Harrison pick, under the same air pressure.

The chief point of difference between these machines and the rock drill is that the bit of the pick machine need not rotate, because it is not intended to make a round hole. The rifle bar and nut are, therefore, omitted in the Harrison, as well as in the earlier and latest forms of the Ingersoll pick. This feature renders them stronger and more durable than the rock drill. On the other hand, while they are generally subjected to very rough usage, their work in the relatively soft coal is not so trying as that of a drill operating in hard rock. Under ordinary circumstances with a pick machine a skilful man can cut from 250 to 500 square feet per shift (including the usual delays), at the following approximate cost:

Wages—Machine runner........	$2.25
Wages—Helper	1.50
Power, repairs and oil..........	1.50
	$5.25

or, say, from 1 cent to 2 cents per sq. ft. The number of tons undercut depends obviously upon the thickness of the seam of coal.

The compressed air pick machines are not economical in their consumption of power, and in fact, the same considerations in this respect apply to them as to rock drills. It may be that in the future they will be rivaled by electric reciprocating machines, one or two of which have lately been brought out (such as that of the Morgan-Gardner Electric Co.), but in their actual work the compressed air machines are found to be decidedly satisfactory, and, as compared with those operated by electricity, are perfectly safe for use in gassy mines.

Underground Compressed Air Locomotives.—Many compressed air locomotives are in successful operation in both collieries and metal mines, but, as they merit a more extended notice than can be given here, they will be dealt with in a future article.—ROBERT PEELE, in *Mines and Minerals.*

Compressed Air Not Likely to Cause Disastrous Explosions.

The *American Engineer and Railroad Journal* calls attention to the fact that while many have the impression that compressed air carried at high pressures is not a safe power, on the contrary, it is less likely to result in disastrous explosions than either steam or gas. When we consider the great number and variety of uses to which compressed air is put it is not strange that accidents do occasionally occur, but they are generally due to carelessness or ignorance.

"Compressed air installations are used with pressures up to 3,000 pounds to the square inch, not only in every mine of any magnitude, in all tunnel work, quarries, shipbuilding, submarine work and for refrigerating purposes, but it has a very wide range of usefulness in all railroad and manufacturing lines. Nearly every railroad, machine, erecting and boiler shop and foundry of any size has its own compressor plant, and from all of these varied sources comparatively few accidents have been reported. As a means of safety many of the powder magazines throughout the country are using compressed air as a motive power, to the exclusion of steam and electricity. Railroad trains, both freight and passenger, are equipped with air compressors and storage tanks, and

on the latter the power is used for as many as eight different purposes, such as the braking of trains, ringing bells, opening fire doors, shaking grates, sanding the rails, lifting tender water scoops, raising water in passenger coaches and operating fans for ventilation.

"The reason why compressed air is a safe power is the fact that it has no reserve force, as in the case of steam boiler explosions, where the destructive effect is caused chiefly from this force; that is, the sudden conversion of large volumes of superheated water into steam, by the reduction of pressure above the water space in the boiler. In the case of air, when a vent occurs, it serves to reduce the strains. This is due not only to the expansion of the air from a smaller space into a large one, but a rapid reduction in volume, due to the fall of temperature in expanding. The failures that have occurred in the use of compressed air can, in nearly every instance, be traced back to the ignition of oil or some inflammable substance which is used with the air. Low-test lubricating oil, for example, fed to the air cylinders, may meet with a temperature greater than that of its flashing point. In putting oil into the cylinders any surplus that may reach the cylinders is forced out through the delivery valves into the air pipes and receivers. The products of decomposition of a large quantity of oil in the receiver would, with the air, form an explosive mixture.

"Air in itself is a perfectly safe fluid, and only requires a vessel strong enough to hold it. In this respect the problem is not a serious one, as the factor of safety in the case of air may be less than for steam, water or gas, as it does not corrode the vessel, its temperature is not changed, and it causes no internal destruction."

A Convenient Air Jack.

A device known as an air jack which will be recognized as an aid to roundhouse repair work in handling the heavy driving boxes now in use has recently been put in operation. The jack consists of a pipe cylinder attached to a strong plank, through which the piston rod extends, an "L" head being attached to the upper end. The required bore of the cylinder depends upon *the air pressure* carried in the shop, and the maximum weight of the driving boxes in use, enough piston area being provided to insure the raising of the heaviest box. The cylinder should be made as long as the depth of the pits will allow in order to obtain as long a stroke as possible, and the cross plank should be made of the proper length to go between the rails. To operate, a thin metal plate is laid on the "L" head, the driving box placed in position and the air turned on, when the box will be raised to the desired position in the jaws. If the engine is so high that the length of the stroke is insufficient to raise the box to the proper height, it may be blocked up, the piston lowered and additional blocking placed on top of the "L" head, which will be sufficient to gain the distance. The jack has shown its practical utility in the Chicago, Burlington & Quincy shops at Aurora, Ill., where it has been in use for some time. —*Railway Age.*

Equipment for a Small Brass Foundry.

I recently had occasion to estimate the equipment for a small brass foundry, and I send you the sketches of the plant which I designed, showing the arrangement. The building can be built of wood or brick, as desired.

Fig 1 is a plan of the foundry, and Fig. 2 shows a sectional elevation. As will be seen in Fig. 1, the building is divided into two sections, the small one being used for an office and the larger for the foundry. In this foundry on the right are three furnaces, with a core oven built over the flue, arranged with a sliding damper which takes part of the waste heat through it to dry the cores. On the left are the benches. Tubs are not much used; they are considered unhandy, as with them the sand cannot be as easily handled. The sand is tempered on the floor and then thrown back against the wall for further use.

One of the features introduced was a crane, with air hoist, so arranged that it could be turned around and cover nearly the entire floor, lifting the pots of melted metal from the furnace and removing the ashes from the pit.

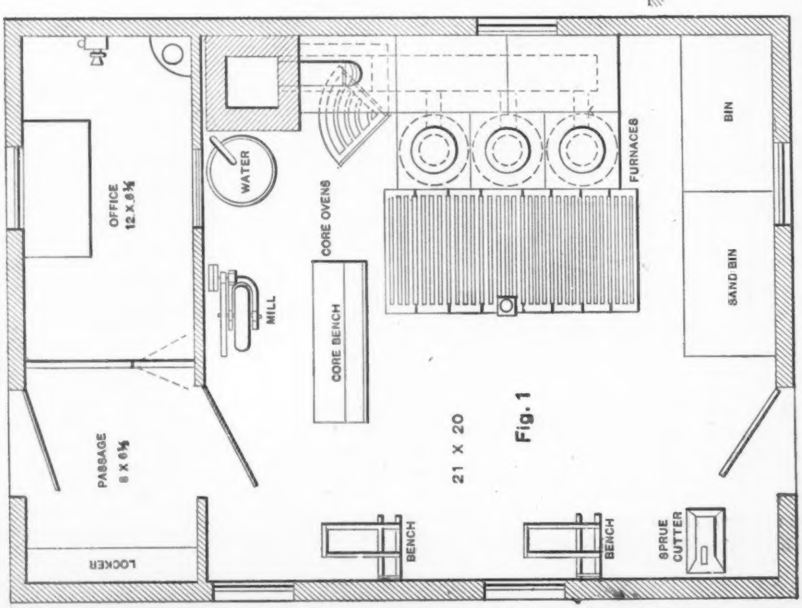


Fig. 1

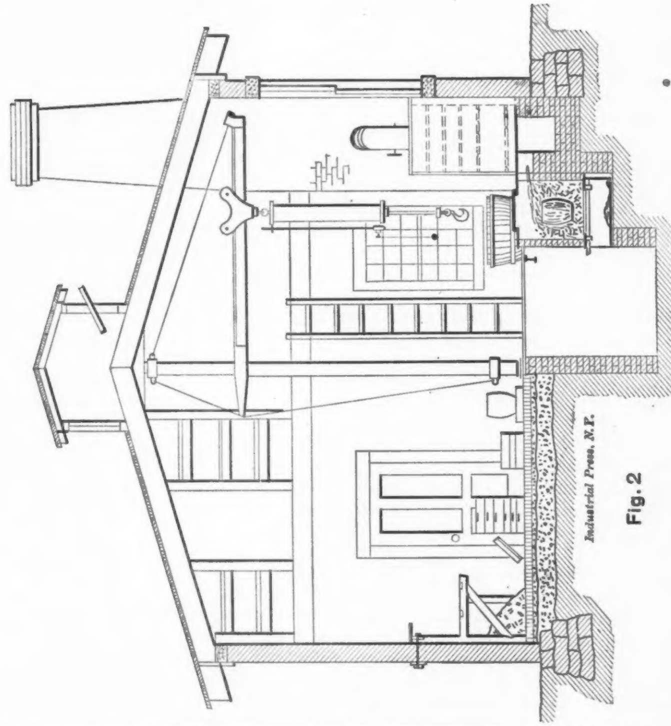


Fig. 2

PLAN VIEW AND CROSS SECTION.

Over the office is a loft with shelves on one side and a space for an electrically-driven air compressor with receiver to supply air for hoisting, dusting, rapping and chipping. The electric motor when not driving the air compressor is used to run the mill for grinding the cinders.

The sketch is of a small-sized foundry, but where more room and benches are needed the foundry can be enlarged in proportion.—WM. F. TORREY, in *Railway Machinery*.

Tools for Repairing the Boyer Long-Stroke Pneumatic Hammer.

"PNEUMATIC."

Having had considerable experience within the past two years in repairing pneumatic tools of various kinds and makes, I submit sketches and descriptions of a number of shop tools and devices which may be of interest to other machinists doing similar work. This article will deal with the Boyer long-stroke riveting hammer, but I do not wish to be understood as inferring that this pneumatic tool requires more attention than other makes. I think that it is a marvelous tool in its work and endurance, but it

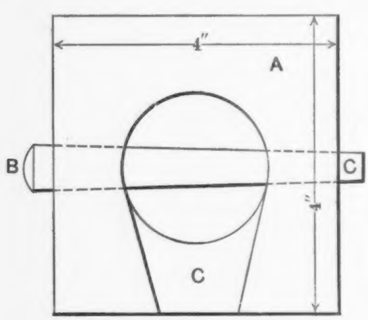


FIG. 1.

pays to use all pneumatic tools properly and always watch for any defects that may develop from continued use. The best made tools of any kind must wear when used and eventually require renewal of worn parts. Again, the presence of dirt or other foreign substance in any tool may seriously interfere with its action, and such is particularly the case with pneumatic hammers. Tools are required to take them apart quickly, and some special ones are quite necessary for doing it without damage to the internal mechanism.

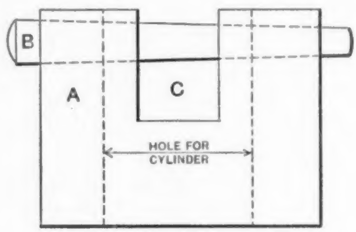


FIG. 2.

In the first place, it is necessary to hold a pneumatic hammer in the vise when taking it apart. It is not advisable to grasp either the cylinder or the handle in the vise, as the pressure required to hold it firmly may squeeze it out of shape and ruin it for future use. Figs. 1 and 2 show

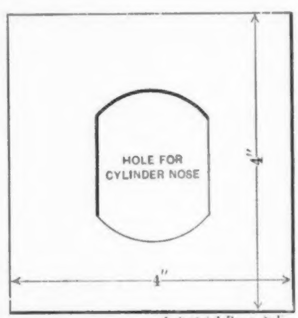


FIG. 3.

a wrought-iron block A for holding a hammer in the vise. It is four inches square and two inches thick and is drilled and cut out for the handle as shown so as to slip over the cylinder of the hammer and onto the handle. The handle drops into the recess C far enough to allow

the taper pin B to pass and thereby lock the handle in the block. The block can be firmly held in the vise without danger of injuring the hammer while separating the cylinder from the handle. A long spanner is then used to unscrew the cylinder.

Fig. 3 shows another wrought-iron block of the same dimensions as that shown in Figs. 1 and 2. It is used for taking off the cylinder nose. A hole the size of the nose across the flats is first bored through the block and then slotted out so as to fit the circular part. It forms a lock block and has no tendency to squeeze the nose together as would be the case if it were held in the jaws of the vise.

I find the steel claw, Fig. 4, most useful for pressing down the spring lock, which must be done before either handle or the cylinder nose can be screwed off. It is made of ¼-inch round steel flattened at the end and filed out as shown to fit the teeth of the lock, and then hardened.

It very often occurs that the automatic stopping valve has to be ground to its seat. For this purpose the brass mandrel shown in Fig. 5 is used. It is turned to fit the valve and the end is split into three divisions by three saw cuts. A taper head screw is provided for expanding the

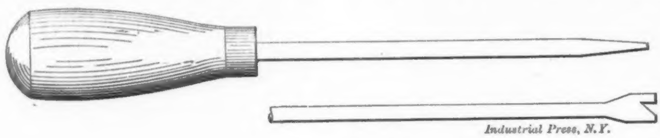


FIG. 4.

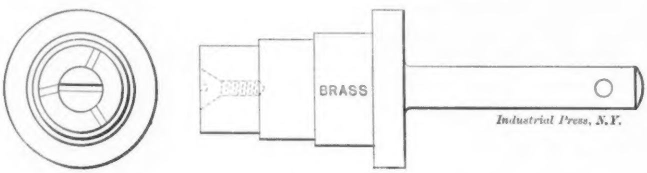


FIG. 5.

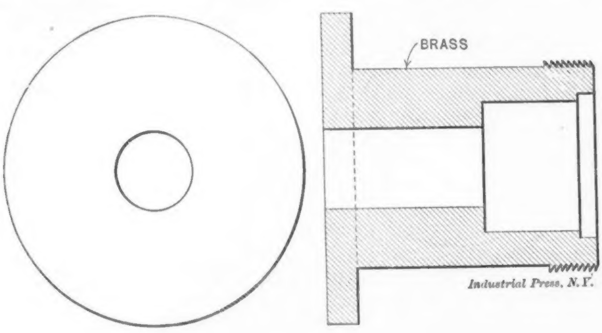
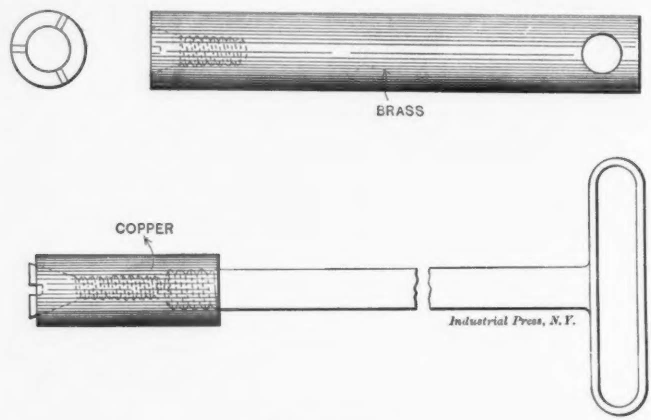


FIG. 6.

end of the mandrel and tightening it into the valve. The valve should not be driven onto the mandrel, but should slip on easily. The remainder of the mandrel is turned to fit the end of the cylinder. The mandrel shown has three sizes turned for reasons that anyone making one will readily see. A hole is drilled through the handle at right angles for the insertion of a rod to turn the mandrel by while grinding. A few minutes' grinding will generally suffice to make the seat and valve tight.

I have frequently been troubled by air breaking through the face of the "rear valve lid" and getting behind the piston, causing it to work slowly when not in actual use. It may be thought that the automatic valve, if tight, should prevent this, but air leaking by the inner face of the valve lid, enters the cylinder inside the automatic valve. Of course, the principal reason for the leakage and slow working of the piston is the throttle valve not being tight, but this being a piston valve it cannot be made tight except by making a new one and grinding it in place. A much quicker and simpler way then is to grind the face of the valve lid to the seat in the handle. For doing this I use the device shown in Fig. 6. It is made of brass with ratchet teeth and screws into the handle in place of the cylinder. Before putting it into place, the valve lid is mounted on the mandrel shown in Fig. 7, which has a split end like that shown in Fig. 5. The spring belonging to the valve is also put on the



FIGS. 7 AND 8.

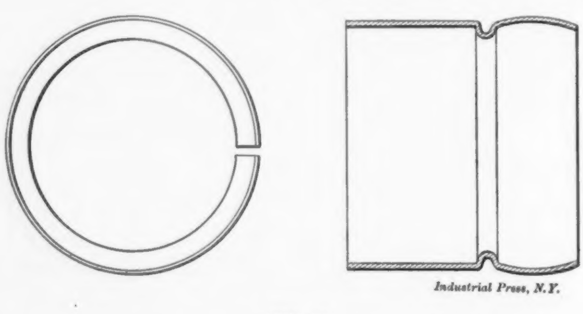


FIG. 9.

mandrel and then the mandrel is slipped through the hole in the piece, Fig. 6. The latter is then screwed into place and the spring gives the proper pressure on the valve while grinding. A hole is put through the outer end of the mandrel for a piece to turn it while grinding. Flour emery is used for grinding all valves and other parts.

It frequently occurs that a piece of dirt or scale gets into the cylinder and cuts a rough spot or groove in one or two places. Should this occur I use an adjustable copper lap, Fig. 8, to grind down the roughness. It is made adjustable the same as the mandrels already described and has a handle somewhat longer than the cylinder, screwed into it. The lap is worked to and fro carefully, using a very little flour emery and oil in the operation. This is only done as a last resort.

A great convenience for the men using these hammers, is the shield shown in Fig. 9. I noticed that they were continually wet by the moisture in the exhaust and often their clothing was soaked. The shield was made to deflect the exhaust. It is made of Russia iron to the shape shown, and is sprung over the largest diameter of the handle, leaving sufficient space for the exhaust to pass out freely but away from the operator. A very few minutes after the first one was made and applied, I received orders to make similar shields for all the hammers in use, and the men think they are the best thing that ever happened for their comfort.—*Railway Machinery.*

The Morrison Automatic Air Safety Valve.

Everyone who is connected in any manner with the handling of air-brake trains has realized the serious consequences generally attendant upon the accidental release of the train line pressure by the train parting or the rupture of a hose, the air thus suddenly escaping from the train pipe, the brakes are applied instantaneously, seriously endangering life and property in passenger trains and causing much damage by the shifting of the loads in merchandise trains. The consequent damage to car bodies and draft appliances is well known. Moreover, many collisions occur between the rear sections and forward sections of parted trains, due to the fact that the stoppage is automatically accomplished on both sections (with the present system), as the train in parting passes entirely out of the control of the engineman. The braking power in each car varies, due to many changeable elements entering into the brake construction, such as the relative brake leverage, the friction, piston travel and the matter of developed friction throughout the entire brake mechanism. As a result one car may have greater holding power than others. The proportionate number of air-brake cars ahead of the brake, and the number at the rear, also has a bearing upon the length of time in which both sections of the train may be brought to rest, and should this difference be such that the forward section of a parted train would have all brakes serviceable and the rear section have but one-half serviceable, a collision would be the inevitable result.

The Morrison automatic air safety valve is designed to obviate such casualties and damage by causing the rear section of the train to be brought to a gradual stop and at the same time allow the front section to be in perfect control of the engineman, which will permit him to advance far enough so that a collision will not take place between the two sections.

The accompanying engravings illustrate a longitudinal section view of this device, the dotted lines showing the movable piston and stem in their normal position with stops on inner wall of cylinder, which limit the downward movement.

When the engineman admits the air into the train pipe it will flow to the enclosed chamber above the piston, and as the piston has no packing the air will pass between it and the wall of the cylinder and fill the lower chamber, producing equal pressures above and below the piston.

When the train breaks apart and the hose becomes disconnected the sudden discharge of air from the train pipe relieves the pressure on top of the piston, forcing the piston upward, in its travel passing the port in the cylinder, allowing the compressed air from the train pipe to pass below the piston, completing its stroke and holding it in position, the stem closing the main pipe line.

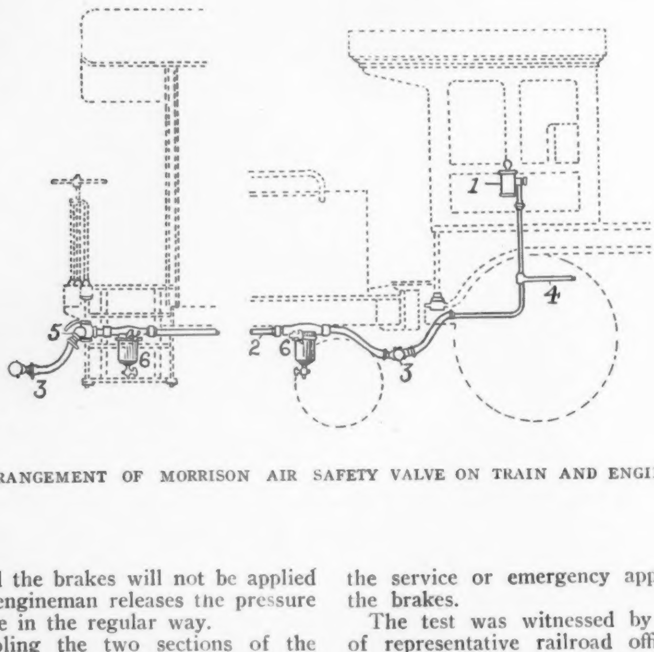
The air in the train pipe slowly dis-

charges through the small hole in the top of the cylinder to the atmosphere, allowing the brakes to be applied throughout the rear section of the train gradually and without shock.

The action of the safety valve at the rear of the front section of the train acts in a similar manner, but as the train pipe of the front section is in communication with the main reservoir upon the locomotive, the discharge of the air through the small holes in the top of the cylinder will be replaced, the pressure will be retained and the brakes will not be applied until the engineman releases the pressure in the pipe in the regular way.

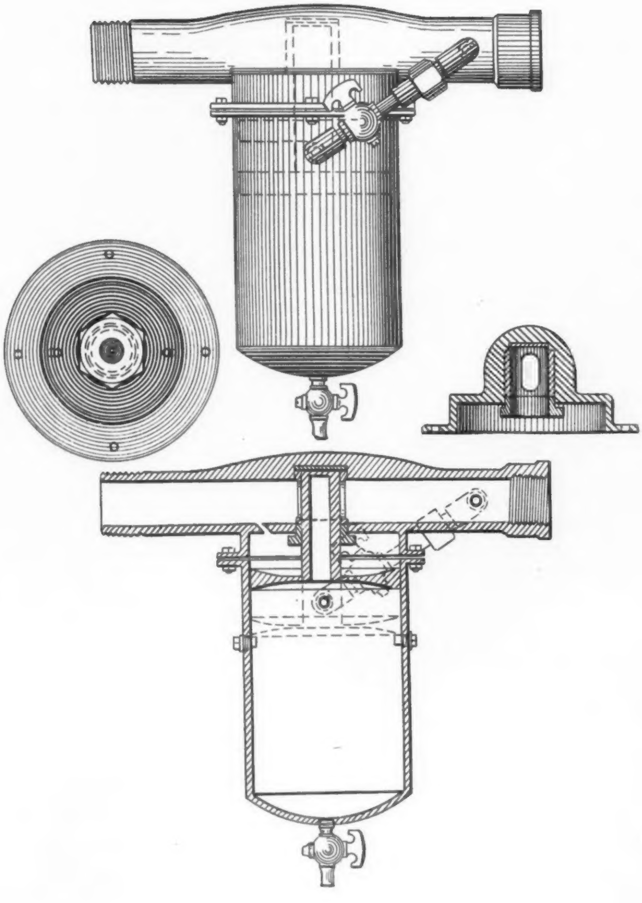
In coupling the two sections of the train when brought together the stop cock is turned, shutting off communication between the train pipe and below the piston; then the stop-cock on the bottom of the cylinder is opened, allowing the air to escape to the atmosphere, whereupon the piston and stem drop to their normal position.

In a service test, made in the Pennsylvania's Company's yards at Toledo, O., on February 10, 1902, with a train of heavily loaded cars running at a speed of 15 miles per hour, the train being broken, the rear section came to a stop without shock at 200 feet from where the train hose parted, and the front section was under perfect control of the engineman, the same as though a "break-in-two" had not occurred. The attachment of these valves on the train pipe did not in any way interfere with or obstruct the free passage of air through the train pipe and subsequent recharging of the train pipe system, nor with the proper making of the service or emergency application of the brakes.



ARRANGEMENT OF MORRISON AIR SAFETY VALVE ON TRAIN AND ENGINE.

The test was witnessed by a number of representative railroad officials from prominent roads, who expressed the opinion that the tests had proved successful in every way. A company has been organized at Toledo to manufacture this valve, and the following officers have been selected: President, O. P. Bowman; vice-president, Eli A. Stark; treasurer, T. F. Whittlesey; secretary, Walter H. Bowman; manager, Frank B. Morrison. The company has been capitalized at $150,000.—*The Railway Age.*



MORRISON AIR SAFETY VALVE.

Notes.

At the great Louisville Cement Mills, Louisville, O., compressed air is used extensively for power purposes, the rock drills in the stone quarries being driven by air.

The Garry Iron & Steel Co., are now engaging more extensively than ever in the production of structure material. Among other large orders they are building a pneumatic portable crane for the Atlas Works of the Standard Oil Co., at Buffalo.

Mr. J. D. Hurley, formerly vice-president and general manager of the Standard Pneumatic Tool Company, which company is now owned and controlled by the Chicago Pneumatic Tool Company, has been appointed manager of the Chicago Pneumatic Tool Company, with headquarters at Chicago.

We were rather taken back at reading in a Paris daily paper that the price of a *carde-lettre pneumatique* had been reduced from 50 to 30 centimes (10 to 6 cents); but a frequent visitor to the gay city explains the mystery by informing us that *pneumatique* is the current expression for a message sent through the pneumatic tube to distinguish it from the ordinary telegram.

The amount of air required by a rock drill is usually estimated at fifteen cubic feet at sixty pounds pressure per minute for a three-inch drill and twenty cubic feet for a 3½-inch drill. It is false economy to use too small a compressor for a given number of drills. In estimating the size of a compressor to drive six drills figure that three drills will be working at any one time.

The Stilwell-Bierce & Smith-Vaile Company of Dayton, O., states that O. G. Smith is now manager of its branch office at 612 Arch street, Philadelphia. A. L. McClurg, who has been with the Harrison Safety Boiler Works for six years, has become a salesman of the Stilwell-Bierce & Smith-Vaile Company's pumps, feed-water heaters, etc., making his headquarters at Pittsburg, Pa.

The manufacture of pneumatic tools at the Havana Bridge Works, Montour Falls, N. Y., will be carried on under the management of J. A. Shepard, vice-president. This company recently sold that portion of their plant devoted to the manufacture of bridge and structural work, to the Rochester Bridge and Construction Co., Rochester, N. Y., and will confine their interest hereafter entirely to the manufacture of pneumatic tools.

From the annual report of the board of directors of the Pennsylvania Railroad Co., to the stockholders, March 4th, 1902, we learn that the pneumatic automatic signals were completed to Paoli, the revision of the line and the construction of the four-track system completed at Rheems, on the Philadelphia Division, and the under-grade crossing at Market street partially constructed under the agreement with the municipal authorities of Harrisburg.

The pneumatic caisson for the Brooklyn tower of the Third East River bridge was towed from the construction yard at 151st street and the Harlem River to its location at the foot of Washington street, Brooklyn, on March 17, and the work is now in progress preparatory to the sinking. This caisson is of wood, 144x78 ft. in plan and 56.29 ft. deep. It will be surmounted by masonry tower foundations 58.21 ft. high, which will carry a steel tower 325 ft. high.

Here is where you get rid of that tiresome valve. The Illinois Pneumatic Hammer does the deed, and withal is so simple, strong, quick, that at the end of the thirty days' trial you wonder how you ever got along without it. Th trigger is protected and in a natural position. There it no jarring of the handle, making it perfectly safe, while it strikes a heavy decided blow, or a light one, which ever is suited to your work. These pneumatic hammers are manufactured by the Illinois Pneumatic Hammer Co., 918 N. Sawyer avenue, Chicago, Ill.

A locomotive type of air compressor will be used in connection with the power installation at the new storage and cleaning yard of the Harlem R. R., which is

built at North White Plains. This air compressor will be used in the boiler room and will deliver air into a receiver tank located outside of the building, which connects to a 2-inch air pipe placed on the same rack as the steam and water pipes around the inside of the rear wall of the engine-house, with a 1-inch globe valve connection between alternate engine pits. A locomotive-type air compressor will be used.

The ninth annual convention of the Air Brake Association will be held in Pittsburg, Pa., on April 29. The Monongahela House has been selected as headquarters, and members are requested to stop there while in the city attending the meeting. It is hoped that members of the association will be able to obtain exchange passes, in order to attend this meeting, and if such is the case an excellent attendance is anticipated at the convention. Further particulars desired by those wishing to join the association may be had by application to the secretary, F. M. Nellis, Havemeyer Building, New York City.

One would as soon think of committing railroad suicide as to thoroughly equip a train of passenger cars without the regulation air brakes, whether they be of the Westinghouse make, or that of any other of the well known manufacturers. We notice a smart, up-to-date little railroad of twenty-six miles, which extends from Grand Rapids to Holland, called the Grand Rapids, Holland & Lake Michigan R. R. The passenger equipment consists of ten closed cars with seating capacity in each car for over fifty people, each car being supplied with the Magann Storage Air Brake, the air compressor for the charging of the reservoirs being installed at the power house and the Macatawa sub-station.

At the annual meeting of the Compressed Air Company, operating the Rome Locomotive Works at Rome, N. Y., the following directors were elected: Henry D. Cooke, New York; A. C. Soper, Washington; H. Monkhouse, Rome, N. Y.; C. S. Truax, New York; Thomas B. Kent, New York; D. C. Morehead, New York; C. H. Buell, New York; A. B. Proall, New York; Newell C. Knight, Chicago. Officers were elected by the directors as follows: President, Henry D. Cooke; vice-president, H. Monkhouse; secretary and treasurer, H. A. Hinely. It is stated that the financial difficulties of the company have been overcome by funding the floating debt. Of the company's authorized issue of $500,000 bonds, $300,000 are outstanding. About $50,000 is to be expended upon the Rome plant for improvements and additions. There is at present about $100,000 worth of material on hand.

The University of Chicago has recently installed a new heating, lighting and power plant in which compressed air figures largely, as is the natural order of things. It is used for automatic heat regulation, and for use in experimental work and water at high pressure for fire protection and to supply all parts of the various buildings. An air pump in the engine-room operates to maintain an air pressure of 80 lbs. per square inch in a reservoir from which are run receiver lines to the various buildings for use in laboratories for experimental work and in the apparatus for the automatic regulation of heat, after reduction in pressure. In the boiler room, compressed air from this source is employed to clean the boiler tubes and the water and air heating pipes in the smoke ducts. All machinery is lubricated under pressure afforded by the compressed air, and the air is also used in a brazing furnace and in a number of other useful ways.

In order to furnish storage and protection to the southern part of the Metropolitan water district, Boston, Mass., in case of accident to pumps or mains, and to provide for sudden and unusual droughts, a reservoir was built at Forbes Hill, in Quincy, near Boston. When the time came for the calking and riveting, so far as it was possible the people who had the matter in charge desired to have the work done with pneumatic tools, power for which was furnished by a 25 horse power boiler and 12 horse power Clayton Air Compressor, carrying a pressure of 100 to 110 lbs. per sq. inch. A round-nosed calking tool was used and great care taken not to injure the under plate. The use of drift pins was not allowed to force the rivet holes to coincide, any holes more than 1-32-in. out of center being reamed. The side plates were first set up

with bolts, and when all were in place the riveting was begun at the top and worked downward, except in the case of the lowest two or three courses, when the riveting kept pace with the erection. The work of erection was finished Nov. 20, and on Dec. 13, 1900, all riveting was done.

Where compressed air is used Quick As Wink Couplers should certainly prove of much value, and as the W. J. Clark Co. themselves quaintly express it, "These couplers won't come apart until you take them apart, and that you can do 'Quick As Wink.'" No twisting and turning will make them let go their hold on the hose—the couplers swiveling freely to unwind the hose, which lasts much longer because thus relieved of twisting strains. Notwithstanding its extreme simplicity of construction, this coupler is not easily damaged, and will stand more abuse than screw couplers. There are no threads to become crossed or battered, and even when slightly flattened are still of use, though in this condition the screw couplers would be almost useless. One piece of hose can be made to serve in the place of many pieces, as only a moment's time is required to detach from one place and attach at another place. If the cost of one section of hose is saved, Quick As Wink Couplers should be a paying investment, and we wish the W. J. Clark Co. the continued success it deserves.

A novel use of compressed air is to be seen in the machine shops of the Hendey Machine Company, at Torrington, Conn. They cut a good many long screws, mostly with square threads, for lathe lead screws and for other transmission screws. The usual trouble was experienced with them from expansion. The temperature of such screws is of course raised considerably during the cutting operation, and much care had to be exercised to prevent this rise in temperature from making trouble and causing too great a departure from accuracy in pitch. Lard oil is used as a lubricant on the screw tool and now in addition to that they have over each lathe a rubber tube through which a blast of air is delivered. The end of this tube is secured to the lathe carriage, and it is so arranged that it moves with the carriage and plays a constant stream of cool air upon the work and the tool. This air carries away the surplus heat as fast as it is developed, keeps the temperature of the work down to about the temperature of the lathe and of the room, does away with the necessity of all waiting or other means of cooling, and enables accurate work to be done much more rapidly than was practicable before the air service was put on.

At the temporary yards of the Eastern Shipbuilding Company, Groton, opposite New London, Conn., a power house has been built exclusively for driving the machinery and compressing the air for the pneumatic tools. Here are the two compound steam and air piston intake compressors built by the Ingersoll-Sargeant Drill Company which have inter-coolers and superheaters and deliver the air at 100 pounds pressure. The capacity of the small machine is about 1,500 cubic feet of free air per minute, and that of the larger machine about 2,000 cubic feet. A Wheeler condenser with 3,000 square feet of tube cooling surface is mounted over a Blake compound air and circulating pump and receives the exhaust steam from the entire plant.

The compressed air from the compressors in the engine room is led to two vertical cylindrical receivers at the after end of the shipbuilding berths through an 8-inch pipe, and from here is distributed through several mains running the length of the berths. From these it is tapped into rubber hose leading to headers and then distributed to the different tools. Pneumatic riveting has been used almost exclusively in all ship construction work at this yard.

The Allis-Chalmers Company, Fraser & Chambers works, Chicago, Ill., issues the fifth edition of its catalogue No. 46 on Riedler compressors and blowing engines. Like all publications of the Allis-Chalmers Company, this pamphlet of 186 pages is well bound, neatly printed and has numerous fine illustrations. It contains some remarks on compressed air and then takes up in detail the construction of the Riedler compressor, showing by numerous diagrams the differences between the Riedler air valve and air valves of ordinary type. The compressors are built either single or duplex, direct acting or two stage, to be driven by water wheels, turbines or steam

engines. Some of the notable compressors constructed by the Allis-Chalmers Company are shown as they appear when set up for use. One of these is a King-Riedler compressor recently built for the Rand Mines in South Africa. The capacity of this compressor is 7,000 cu. ft. of free air per minute to a pressure of 80 lbs. per square inch. The Calumet & Hecla Mining Company, of Michigan, is to install two double two-stage Riedler air compressors driven by duplex cross-compound vertical King-Corliss engines, capacity of each being 14,000 cu. ft. of free air per minute to a pressure of 75 lbs. per sq. in.

H. K. Porter Company of Pittsburg, Pa., have recently installed a number of large haulage plants throughout the United States. Among these may be mentioned a complete tramway system for the new reducing works and stamping mills of the Anaconda Copper Mining Company of Anaconda, Mont., air motors to be employed for handling all the concentrates fuel, ore, etc., throughout their entire mill district; also two plants of considerable importance for the Cambria Mining Company of Cambria, Wyo., and a plant for the Homestake Mining Company. The company have further completed and installed for the United States Naval Power Depot at Lake Denmark, Dover, N. J., one 12 by 18 inch pneumatic locomotive, built with compressor, charging stations, receiver, etc., the locomotive being employed in handling cars loaded with amunition and distributing the same to the various magazines. A similar plant was installed a year ago for the United States Naval Magazine at Iona Island, N. Y. Of the other work, a large number of orders have been received for pneumatic locomotives for use in powder works in the far West and for handling lumber in industrial establishments, a plant of the latter sort having just been completed for the McCormick Harvesting Machine Company of Chicago.

There are few railroads to-day which have not tried pneumatic tools for one purpose or another, finding them satisfactory in not only their quick and efficient work, but in the matter of expense as well. No argument should be necessary to demonstrate their earning capacity, but the value of air jacks for cars and locomotives is not so generally known. It formerly required about four hours for eight men with screw jacks to take a ten-wheel engine weighing 132,000 lbs. off its drivers, at a cost of $5.14, and about half that time for four men to do the same work with hydraulic jacks, but using four pneumatic jacks, it is now regularly done by four men in one hour at a cost of 66 cents. However, to be strictly up-to-date an electric crane should be used and the time reduced to ten minutes.

A pneumatic ram was recently made at a cost of $168.55 for breaking staybolts to remove worn-out fireboxes, which earns very large interest on the investment. It formerly cost $45.60 to cut out the crown bolts and staybolts of a ten-wheel locomotive with 9-ft. firebox, using three men, but with the pneumatic ram it is done by two men for $15.20, thereby saving $30.40 on each firebox. If only one firebox was removed each year this tool would earn 18 per cent. on the investment, but as the shop applies 30 new fireboxes a year the saving amounts to $912, or 541 per cent. per annum on the amount invested.

In doing a large class of lathe work much time is used up in starting, stopping and reversing the machine. On brass work especially, such as machining valves, cocks and nuts, where it is necessary to reverse for thread cutting, the lathe is run at a high speed, without back gears, and the time spent in operating an ordinary countershaft may be conservatively estimated as 20 per cent. of the entire time spent on the work.

It was for saving time on this class of work that the pneumatic belt shifter and brake was devised. With this appliance the belts are shifted and the brake is applied by the movement of the hand lever of a pneumatic valve, placed on the lathe apron where its nearness to the other levers of the apron makes it convenient of operation. In it there are five parts, any one of which may be utilized by moving the lever so that the valve covers the desired port. The valve itself is connected, by a flexible tube, to the general air supply pipe of the shop.

The central position of the lever is the "stop" position; when the lever is placed here the driving belts are thrown out of

action and a brake is applied to the lathe spindle. The port on the left of this is the "forward" port, while the one to the right is the "back" port. The two outer ports are release ports for the cylinder of the pneumatic brake. When running forward, if it is desired to run back, the lever is thrown directly from left to right, passing over the central port.

Air compression in stages greatly diminishes the influence of the dead space owing to reduction in the ratio of compression for each cylinder, and accordingly it permits of attaining very high pressures, the advantage being greater the more cylinders there are. There are also the additional advantages of less variation in the resistance opposed to the motors, and diminution in the escape of air at the pistons and valves, these parts being subjected to a more favorable regime of pressures. All these effects contribute to increase the mechanical yield; but on the other hand, resistance to the passage of air from one cylinder to another causes additional loss of load, which partly counterbalances the advantages, while the plant is more complicated, and, therefore, costly. Accordingly, simple compression is generally employed when the ratio of compression does not exceed 1 to 7, or 1 to 8; but there is advantage in making an exception for large installations. The necessity of having several motive cylinders for a double or triple expansion of the steam then permits, without increasing the number of parts, a coupling to them tandem-fashion, of the same number of compressing cylinders; and for very high pressures compression in stages imposes itself, for instance, in compressed-air haulage plants when pressures of 30 atmospheres (441 lbs. per square inch) to 50 atmospheres (735 lbs. per square inch) are currently attained.

Have you ever heard of a "Dummy Helper?" *Railway and Engineering Review* says its a small air motor designed for the Aurora shops of the Chicago, Burlington & Quincy R. R. This motor is mounted transversely on a cast iron four-wheeled truck and used for drilling out the vertical holes in cylinders or other jobs that may be easily reached from the floor. The base on which the motor is secured is arranged in such a manner that it may be raised or lowered in two curved guides, and the angle of inclination of the shaft of the air motor thereby altered. A bolt attached to the back of the base passes through the slots in the guides, and it is secured rigidly by setting up nuts on the two ends of this bolt. The drills are set in sockets and operated by small shafts of such lengths as is convenient for the work in hand, these shafts being fitted with unisersal joints to transmit the rotating motion of the air-motor shaft to the drills. This device has proved very useful and is sufficiently rigid as to make the blocking of the wheels unnecessary. It is mounted on cast iron wheels of 5½-in. diameter, the bed plate of the truck being 2 ins. thick, 14¾ ins. wide and 28 ins. long. The base on which the air motor is mounted is ⅝ by 10 by 14 ins. The guides are slotted on a 12-in. radius and the back of the base can be raised through a vertical distance of 7½ ins., being hinged in front. The axles of the truck are 1¼ ins. in diameter, and the distance from the floor to the top of the bed plate is 6¼ ins.

The old Hudson River tunnel was projected by the late D. C. Haskin, who had an original method of pneumatic tunneling. Work was begun in 1874 by sinking a shaft on the New Jersey shore. From the air chamber at the bottom of the shaft the north tunnel was started, the idea being to construct two parallel independent tunnels instead of one large one. Work was carried on from the crown down each side. Iron plates, flanged, were introduced as the excavation progressed and bolted together. When a section of 10 feet had been built it was lined with masonry 2 feet in thickness, this being afterward increased to 2½ feet.

The novelty of the method of building is now to be mentioned. The heading was cut into steps upon which the men worked. The heading was not supported in any way, the tenacity of the silt being depended upon to act as a barrier between the air and water. The air pressure was maintained about equal to the average hydrostatic head. The system appeared to be correct in principle, but in practice it was found to be almost impossible to maintain proper alignment, as the plates had a tendency to settle before the masonry could be finished. The grade of the

first 300 or 400 feet is, therefore, extremely irregular.

This led to the introduction of the Anderson pilot, which was a 6-ft. tube located in the center of the tunnel and extending from the completed work some distance beyond the heading into the silt. It was thus supported rigidly at each end, and served as a hub, from which to brace and hold the plates. This method was successful in every respect, and there was no trouble in following the lines. Afterward the shield method was introduced, and flanged cast iron plates were substituted for the masonry.

The Westinghouse Machine Co., East Pittsburg, Pa., has entered the field as a manufacturer of blowing engines, and last week Julian Kennedy, of Pittsburg, awarded this concern the contract for the erection of six engines to be installed at the blast furnaces of the Toledo Furnace Co., of Toledo, O., and the South Chicago Furnace Co., of South Chicago. They will cost $175,000. Three engines will be built for each furnace, and they will be so arranged that they can be run as compound or single engines. Each set will consist of two high-pressure and one low-pressure engine. The low-pressure engine will be used as an auxiliary, and when it is in use the high-pressure engine will receive steam at the boiler pressure and exhaust into the receiver from which the low-pressure engine will be supplied. When the low-pressure engine is in use as a simple engine it will receive steam from the boiler through a reducing valve.

Each high-pressure engine will have a steam cylinder 50 inches in diameter, fitted with the most modern design of Corliss valve gear. The low-pressure steam cylinder will be 96 inches in diameter and will be equipped with the same appliances. The air cylinder in all engines will be 96 inches in diameter and the stroke will be 66 inches. The engines will make 60 revolutions per minute. The air cylinders will be equipped with the Kennedy piston inlet and outlet valve.

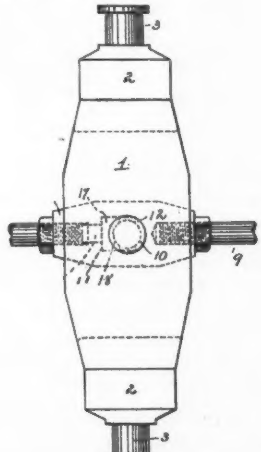
The engines will be of a special type, with the blowing cylinder immediately above a heavy bed plate. On top of the blowing cylinder will be a heavy housing and guide box and on top of the guide box will be the steam cylinder. The advantage is that the engines are very compact. Each will weigh 600,000 pounds, and will have two flywheels 20 feet in diameter, each weighing 65,000 pounds.

The Westinghouse Company has also become a competitor in the horizontal Corliss engine field. It has taken the contract for two such engines of 3,000 horsepower each from the Auburn Interurban Railway Co., of Auburn, N. Y. These engines will cost $70,000. The company has just completed the shipment of eight of the heaviest engines ever built, each having a capacity of 10,000 horsepower. These engines have been sent to the New York Edison Waterside station. The company is also shipping two vertical Corliss engines of 2,000 horsepower each to the new works of the British Westinghouse Co. at Manchester, Eng.

U. S. PATENTS GRANTED FEB. 1902

Specially prepared for COMPRESSED AIR.

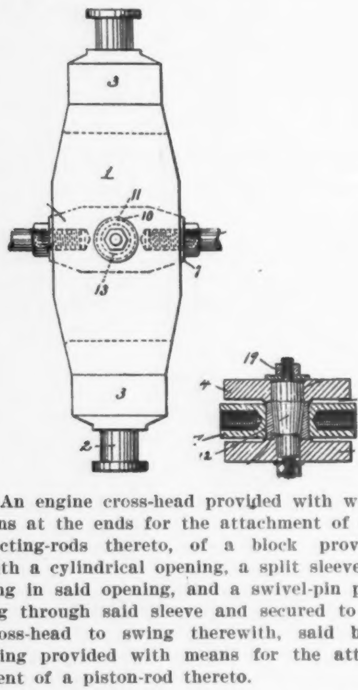
692,287. ENGINE CROSS-HEAD. Fred. D. Holdsworth, Claremont, N. H., assignor to Sullivan Machinery Company, Claremont, N. H., and Chicago, Ill., a corporation of New Hampshire. Filed April 8, 1901. Serial No. 54,979.



An engine cross-head with wrist-pins at the ends for the attachment of connecting-rods thereto, of a block provided with a vertical opening and with a longitudinal opening communicating with the vertical opening, of a piston-rod adjustably secured on said longitudinal opening, a swivel-pin

secured to the cross-head to a swing therewith and passing through the vertical opening, and a wear-plate in said vertical opening between the swivel-pin and projecting into the longitudinal opening against the adjustable piston-rod.

692,288. ENGINE CROSS-HEAD. Fred. D. Holdsworth, Claremont, N. H., assignor to Sullivan Machinery Company, Claremont, N. H., and Chicago, Ill., a corporation of New Hampshire. Filed April 9, 1901. Serial No. 54,980.



An engine cross-head provided with wrist-pins at the ends for the attachment of connecting-rods thereto, of a block provided with a cylindrical opening, a split sleeve fitting in said opening, and a swivel-pin passing through said sleeve and secured to the cross-head to swing therewith, said block being provided with means for the attachment of a piston-rod thereto.

692,368. PNEUMATIC TIRE. Frederick J. Seddon, Manchester, England. Filed April 15, 1901. Serial No. 55,967.

692,393. COMPRESSED-AIR DRILL. Fred Weimar, Chicago, Ill., assignor of two-thirds to S. A. French, Chicago, Ill., and T. D. Hewitt, Freeport, Ill. Filed Jan. 5, 1901. Serial No. 42,207.

The combination with a portable reciprocating-engine cylinder and its piston, of a flexible pipe for delivering motive fluid to the cylinder, a rigid frame extending from the cylinder alongside the path of the piston-rod, two gears mounted in said frame to rotate upon an axis perpendicular to the axis of the cylinder, two racks connected directly to the piston-rod, to reciprocate therewith, and engaging the two gears, respectively, but upon opposite sides, a tool-chuck mounted in the common axis of the gears, clutch devices arranged to transmit to the chuck like alternate movements of the gears, and a slide-valve operated directly by parts accompanying the piston in its reciprocation.

692,424. AIR-COMPRESSING APPARATUS. Justin H. Burdick, Milton, Wis. Filed May 5, 1900. Serial No. 15,570.

An air-compressing apparatus, comprising an air-cylinder, having an air-inlet and air-outlet; a piston movable within said cylinder; a float, adapted to be raised and depressed by the rise and fall of waves; and means, connected to said piston and said float, for causing the piston to travel inward the full extent of its stroke with each elevation and depression of said float, the outward travel of said piston varying in extent with the height of the waves.

692,685. AIR-PUMP FOR GAS APPARATUS. Ferdinand Logan, Phœnixville, Pa., assignor to Thomas Leiper Hodge, trustee, Philadelphia, Pa. Filed April 17, 1899. Serial No. 713,349.

The combination of an air-pump, having a fixed and a movable section, an air-inlet valve constructed to admit air when the movable section is raised, a cylinder, a piston in said cylinder connected to the movable section of the pump, water inlet and outlet pipes communicating with the cylinder, valves in said pipes, a pivoted lever connected to the movable section of the pump, a weighted lever also pivoted and constructed to be periodically engaged by the first mentioned lever, a pivoted arm operatively connected to the valve in the inlet and outlet pipe, said weighted lever being constructed to move the pivoted arm and thereby operate the valves.

692,741. AIR-EXHAUSTING APPARATUS. Henning F. Wallmann, Chicago, Ill., assignor to the Wallmann Engine Company, a corporation of Illinois. Filed July 24, 1899. Serial No. 724,998.

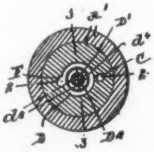
An apparatus of the character described, the combination with the combustion-cylinder and an igniter therein, of an outwardly-

opening discharge-valve closing one end of the cylinder and adapted to be shot open by the force of the explosion, an air-pipe having an annular discharge-opening surrounding the discharge-valve of the cylinder, means for instantly closing the discharge-valve after the exhaust of the products of combustion under the impetus of their own expansion, whereby a vacuum is created in the cylinder, and means for admitting a fresh charge through the agency of the vacuum thus created.

692,796. SHARPENING-MACHINE FOR DRILL-BITS. Theodore H. Proske, Victor, Colo. Filed August 14, 1901. Serial No. 71,996.

A sharpening-machine for drill-bits, comprising a die, and a dolly reciprocating toward and from said die, the die and the dolly having registering bevels to serve as a protection to the shaping part of the dolly and as a guide and bumper for the same.

692,799. PNEUMATIC TOOL. William H. Soley, Philadelphia, Pa., assignor of one-half to George A. Dallett, Philadelphia, Pa., and Thomas H. Dallett, Cheyney, Pa., trading as Thomas H. Dallett & Co. Filed June 15, 1900. Serial No. 20,417.



In a pneumatic tool in combination with a casing, a piston-chamber formed in said casing, a piston of differential area in said chamber, a source of pressure supply, a constant communication between said source of pressure supply and the lesser piston area, a valve-chamber, a valve in said chamber having a closed end, constantly acted on by the pressure-supply, and a chambered portion communicating with the piston-chamber, a piston for said valve, a passage leading from said valve-chamber to the piston chamber and adapted in the reciprocation of the piston to be covered by the piston and open into the chamber below the piston-ports in said valve connecting with the chambered portion of the valve, one port adapted in the movement of the valve in one direction to register with an exhaust-passage and the port in the reciprocation of the valve in the other direction adapted to register with the air-supply, an annular groove b^2 in the piston, a port F extending through the casing to the piston-chamber and a passage H extending from the valve-chamber to the piston chamber opposite port F.

692,948. AIR-BRAKE SYSTEM. Thomas H. Van Dyke, Kansas City, Mo., assignor of one-third to John W. Taylor, Kansas City, Kan. Filed March 11, 1901. Serial No. 50,598.

The combination in an air-brake system, of a lever having a movable fulcrum suitably guided, having a relation with the floating lever whereby its leverage thereon is gradually increased, and pivoted at an intermediate point to the piston-rod.

692,978. GOVERNING DEVICE FOR PNEUMATIC PIANO-PLAYERS. Theodore P. Brown, Worcester, Mass. Filed May 29, 1901. Serial No. 62,344.

A pneumatic governing-device, the combination with a driving-shaft, of a governor-shaft geared thereto, a base-board having a series of air-passages formed therein, said passages each terminating at one end in an elongated port-opening of varying area throughout its length, said series of ports being arranged in parallelism, pneumatic devices attached to said base-board and each having communication with one of the said air-passages, a cranked connection between said governor-shaft and each pneumatic device, and means contacting with said base-board and adapted to control the active area of said port-openings.

693,184. ELECTROPNEUMATIC CONTROL SYSTEM FOR ELEVATORS. August Sundh, Yonkers, N. Y., assignor to Otis Elevator Company, East Orange, N. J., a corporation of New Jersey. Filed Sept. 20, 1901. Serial No. 76,126.

A controlling apparatus for elevators, the combination with a motor, car, and stations, of pneumatic devices and connections for calling and sending the car from one station to another operating in conjunction with the electrical motor-controlling means.

693,195. AIR-SUPPLY TO LIQUID VAPORIZING, COOLING AND AERATING APPARATUS. William H. Weightman, New York, N. Y. Filed July 17, 1900. Serial No. 23,891.

The combination with a cooling-tower open at the top and provided at its upper end with a liquid distributing or spraying appa-

ratus, of a lower compartment open on all sides for the admission of air from without, and through which the liquid passes after treatment; a plurality of radial partitions extending outwardly from the center of said lower compartment; and a liquid drain connecting said partitions, through or along which the treated liquid passes to a receiving-compartment below.

693,198. PNEUMATIC MOTOR. Joseph Weiser, Brooklyn, N. Y., assignor of one-half to Karl Fink, New York, N. Y. Filed Dec. 6, 1900. Renewed Nov. 14, 1901. Serial No. 82,221.

The combination, with a plurality of stationary valve-chests, a suction-chest connected therewith, and an equivalent number of pneumatics also connected with the valve chests, of a crank-shaft connected with the movable members of the pneumatics passing through the valve-chests, and rotary valves fixed at suitable intervals apart on said shaft and working each on one face of each of the valve-chests, said valves and valve-chests being constructed to alternately admit air and shut it off from the pneumatics.

693,366. GENERAL CLASS OF TUBULAR DESPATCH SYSTEMS AND ESPECIALLY TO RECEIVING APPARATUS FOR INTERMEDIATE STATIONS. Bryant H. Blood, New York, N. Y. Filed August 20, 1900. Serial No. 27,455.

A receiving apparatus for tubular transit systems, the combination with a receiving-chamber, pneumatically-operated gates therefor, and a main air-pressure supply for operating said gates, of a governing and controlling system consisting of pneumatically-operated valve mechanisms for said main air-pressure supply, an auxiliary air-supply for operating said valve mechanisms, an excess-pressure valve mechanism, a trip-finger valve mechanism and insurance valve mechanisms, said excess-pressure, trip-finger and insurance valve mechanisms so disposed and constituted as to render each function of the machine absolutely dependent upon the consummation of the preceding function.

693,415. FLUID-PRESSURE SIGNAL-VALVE. Harry R. Mason, Chicago, Ill., assignor to Westinghouse Air Brake Company, Pittsburg, Pa., a corporation of Pennsylvania. Filed June 12, 1900. Serial No. 20,010.

A fluid-pressure signaling system, the combination, with a signal valve device operative by variations of pressure on opposite sides of a movable abutment, of means separate from, but actuated by, the movable abutment, for quickly releasing fluid from one side of the abutment to the other to counteract such variations.

693,431. AIR-RELIEF VALVE. Millard P. Osbourn, Camden, N. J., assignor to Warren Webster and Company, a corporation of New Jersey. Filed Sept. 11, 1901. Serial No. 75,002.

693,434. COMPRESSOR. Frederick W. Parsons, Elmira, N. Y., assignor to Rand Drill Company, New York, N. Y., a corporation of New York. Filed March 11, 1901. Serial No. 50,589.

The combination in a compressor with a base, two standards uprising therefrom and having bearings at their upper ends, and two vertical cylinders arranged one on the outside of each of the said standards, the said cylinders, standards, and base being in one integral casting, of a shaft mounted in the said standard-bearings, a fly-wheel secured upon the shaft and arranged between the said bearings, crank-pins carried by the shaft and arranged one on the outside of each of the said standards, pistons in the said cylinders, connecting-rods connecting the said crank-pins with the said pistons, and an inlet and outlet for the fluid acted upon in said cylinders.

693,484. VALVE-BALANCING DEVICE. Robert L. Ambrose, Tarrytown, N. Y., assignor to Rand Drill Company, New York, N. Y., a corporation of New York. Filed March 11, 1901. Serial No. 50,596.

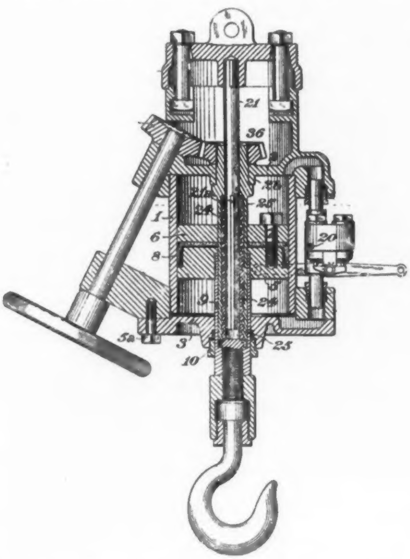
The combination with a valve-chest having ports therein, and a reciprocating slide-valve controlling said ports, said slide-valve having a lateral-extending boss, and having a lateral orifice extending therethrough and through the said boss, of a non-metallic flexible flanged ring, mounted on said boss, said ring free to move on said boss in a direction transverse of the reciprocating movement of said valve.

693,516. MEANS FOR TRANSFERRING FLUID UNDER PRESSURE. William S. Halsey, Pittsburg, Pa. Filed Aug. 30, 1900. Serial No. 28,508.

The combination of a fluid-pressure reservoir, a receiver surrounding and movable longitudinally thereon, a supply-valve seating over a port in the reservoir, a lever system mounted in the reservoir and coupled to said valve, tappets connected to said lever

system, and extending through the shell of the reservoir on the side thereof farther from the supply-valve, and a bearing-surface fixed to the receiver in position to contact with said tappets.

693,517. PNEUMATIC HOIST. William S. Halsey, Pittsburg, Pa. Filed Nov. 13, 1901. Serial No. 82,105.

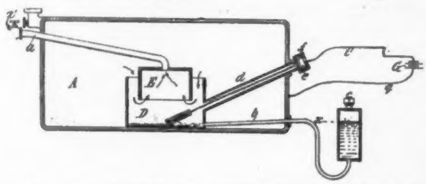


A pneumatic hoist, the combination of a fluid-pressure cylinder, a piston fitting therein, a tubular piston-rod fixed to said piston and projecting through a packed opening in one end of the cylinder, means for admitting and releasing fluid to and from the cylinder, a tubular regulating-screw, fixed to the piston-rod, a rod fixed to the cylinder and extending into the bore of the regulating-screw, a key in said rod engaging a keyway in the regulating-screw, a tubular nut fitting freely in the piston-rod, and surrounding and engaging the thread of the regulating-screw, and means for controlling the speed of rotation of said nut.

693,818. PNEUMATIC TIRE. William F. Stearns, Cambridge, and William L. Haines, Boston, Mass., assignors, by mesne assignments, to Punctnot Tire Company, Camden, N. J., and Philadelphia, Pa., a Corporation of New Jersey. Filed Aug. 17, 1901. Serial No. 72,324.

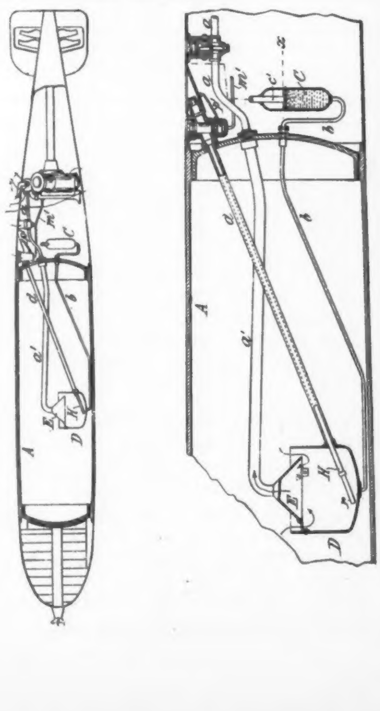
693,823. AIR-GUN. Walter R. Benjamin, St. Louis, Mo. Filed Sept. 11, 1901. Serial No. 75,086.

693,871. GENERATION OF POWER FROM COMPRESSED AIR. Frank M. Leavitt, Brooklyn, N. Y., assignor to E. W. Bliss Company, Brooklyn, N. Y., a Corporation of West Virginia. Filed Dec. 12, 1898. Serial No. 699,006.



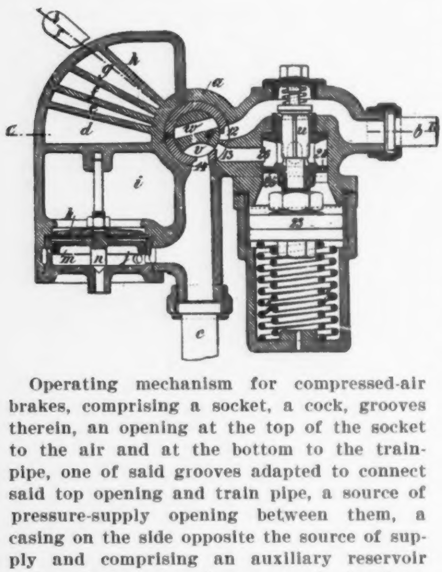
In compressed-air propelling mechanism for automobile torpedoes, the described means for increasing the energy of the stored compressed air which consists in means controlled by the pressure for heating the compressed air.

693,872. PROPULSION OF TORPEDOES, ETC., BY COMPRESSED AIR. Frank M. Leavitt, Brooklyn, N. Y., assignor to E. W. Bliss Company, Brooklyn, N. Y., a Corporation of West Virginia. Filed April 12, 1900. Serial No. 12,545.



An automobile torpedo, the combination with means for storing fluid under pressure, an engine driven by such fluid, and means for starting the engine upon the launching of the torpedo, of means for heating the fluid supply to the engine, and means for starting the action of said heating means adapted to be set in operation by the launching of the torpedo.

693,874. OPERATING MECHANISM FOR COMPRESSED-AIR BRAKES. Joseph Lipkowski, Paris, France, assignor to the Societe Generale des Frenis Lipkowski, Paris, France. Filed Dec. 22, 1900. Serial No. 40,804.



Operating mechanism for compressed-air brakes, comprising a socket, a cock, grooves therein, an opening at the top of the socket to the air and at the bottom to the train-pipe, one of said grooves adapted to connect said top opening and train pipe, a source of pressure-supply opening between them, a casing on the side opposite the source of supply and comprising an auxiliary reservoir and radially-arranged superposed chambers, each having an opening to the socket, a diaphragm in the reservoir, and a valve controlled thereby to open the train-pipe to the atmosphere.

693,939. PNEUMATIC HAMMER. Melvin A. Yeakley, Cleveland, Ohio, assignor to Williams, White & Co., Moline, Ill. Filed Oct. 12, 1900. Serial No. 32,835.

In pneumatic hammers, a hammer-chamber and a valve-chamber and a valve therein, separate vacuum and pressure passages opening into said valve-chamber and a single passage connecting the valve-chamber with the hammer-chamber.

693,991. VALVE FOR PNEUMATIC TIRES. Charles R. Barrett and Elwood C. Phillips, Chicago, Ill. Filed July 12, 1901. Serial No. 67,949.

694,153. MEANS FOR AUTOMATICALLY BALLASTING MARINE BOATS. John P. Holland, Newark, N. J. Filed July, 1901. Serial No. 69,887.

A submarine boat having a tank to contain water ballast, said tank having valve-controlled communication with the water of flotation, means for opening said valve to admit water to the tank, means for admitting an aeriform fluid to said tank for blowing out water therefrom, a hydrometer, electrical means controlled by the rise and fall of said hydrometer for actuating the means for admitting water to and discharging it from said tank, and a float in said tank which breaks the electric circuits established by the hydrometer.

694,154. SUBMARINE BOAT OR VESSEL. John P. Holland, Newark, N. J. Filed July 31, 1901. Serial No. 70,414.

A submarine boat having a tank with capacity, when full, for water ballast sufficient to put the boat in diving condition in fresh water, and an auxiliary tank with capacity when both it and the main tank are full, to put the boat in diving condition in salt water, said tanks being situated with reference to the center of buoyancy of the boat.

694,280. APPARATUS FOR COMPRESSING AIR. Samuel P. Howe and Samuel M. Vauclain, Jr., Ithaca, N. Y. Filed Jan. 15, 1901. Serial No. 43,382.

The herein-described improvement in apparatus for utilizing the operating parts of a steam-engine for compressing air for use in a system of which said engine forms a part, consisting of the combination with a steam-engine and its valve-chest, of a storage-reservoir for compressed air, a liquid-fuel tank, a branch pipe connecting the tank and reservoir for compressed air, a liquid-fuel tank, a communication between said tank and reservoir, a check-valve between said controlling-valve and reservoir, a main pipe connecting the valve-chest of the engine with the branch pipe, a valve for controlling communication between said main pipe and valve-chest, and a check-valve in said main pipe between its controlling-valve and the junction between the main pipe and the branch pipe, whereby when the steam is shut

off from the engine, the latter may operate to compress air and discharge the same through the main pipe into the reservoir and tank, or either of them.

694,299. AIR COMPRESSOR AND COOLER. Oscar P. Ostergren, New York, N. Y. Filed May 24, 1901. Serial No. 61,-773.

The combination with the air-compressor, of the water-injecting pump, the annular inlet to the compressing-cylinder and the annular valve controlling said inlet.

694,324. RECEIVER FOR PNEUMATIC-DESPATCH TUBES. Albert W. Pearsall, New York, N. Y. Filed June 11, 1901. Serial No. 64,167.

A receiving-terminal having a carrier-removal opening made shorter or smaller than the carrier.

694,328. AIR-BRAKE. Charles A. Seley, Roanoke, Va., assignor of one-half to William H. Lewis, Roanoke, Va. Filed Aug. 9, 1901. Serial No. 71,469.

694,339. PNEUMATIC HORSE-COLLAR. Charles S. Boehm, Hopkins, Minn. Filed March 26, 1901. Serial No. 53,014.

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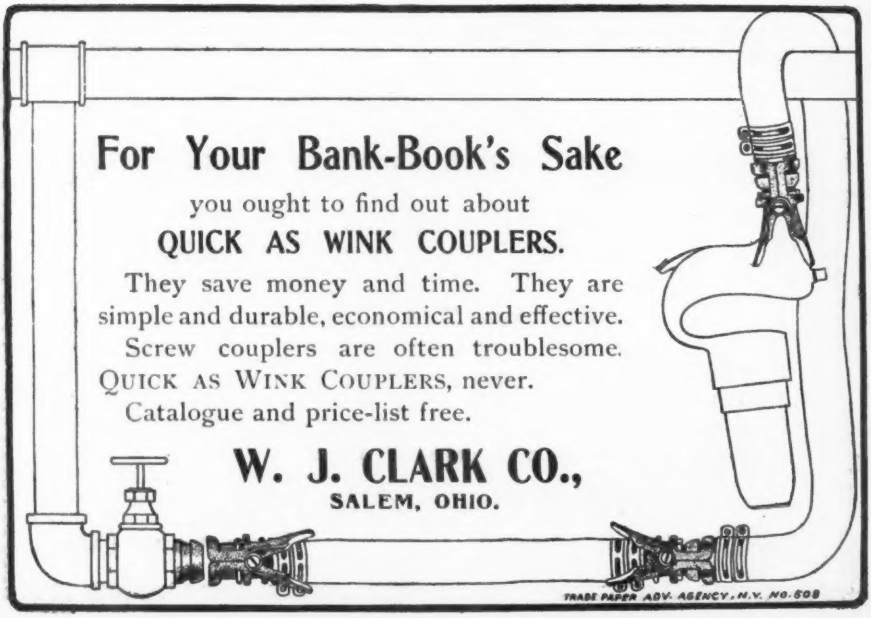

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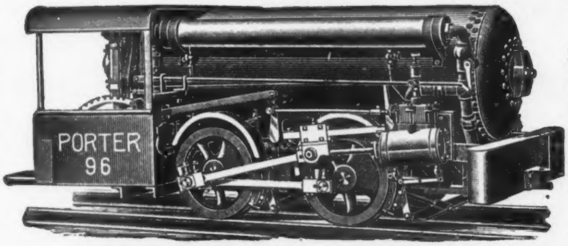

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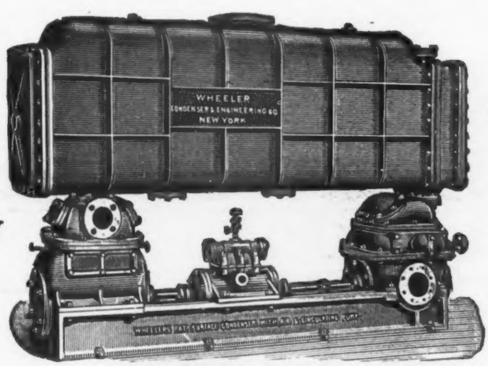

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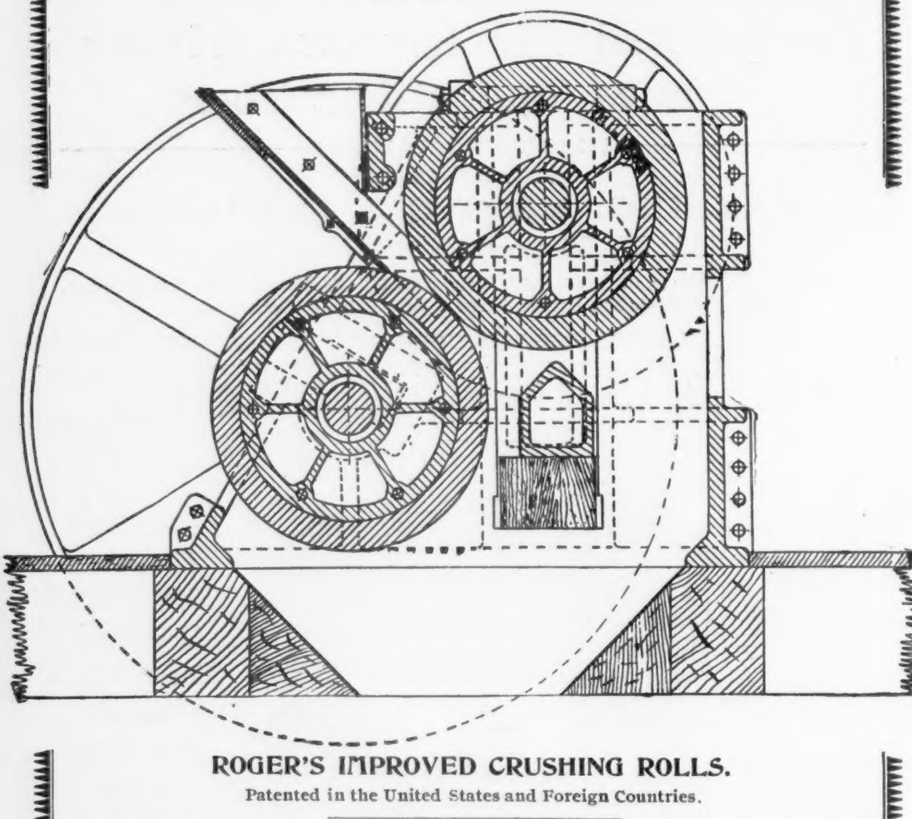

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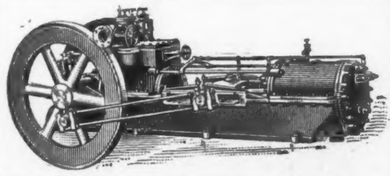

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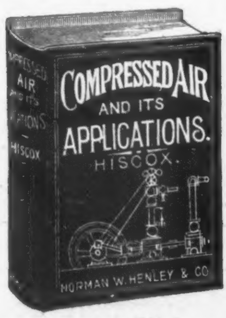

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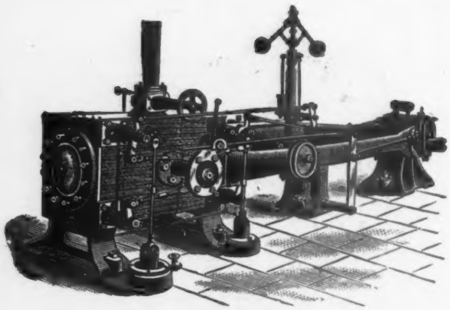

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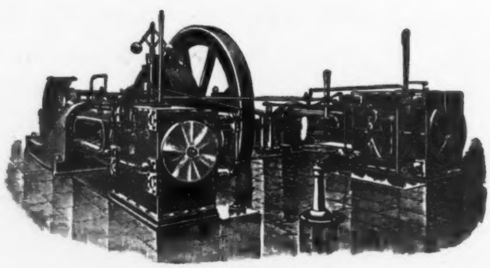

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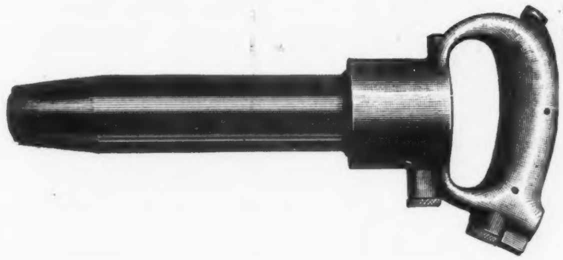

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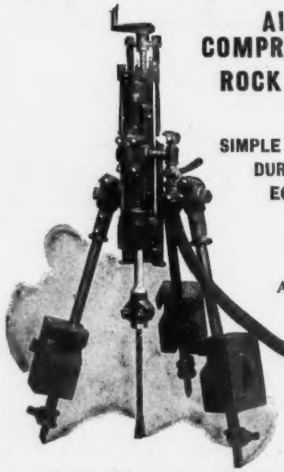

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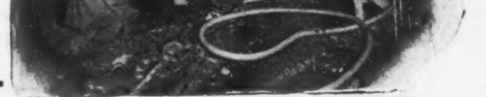

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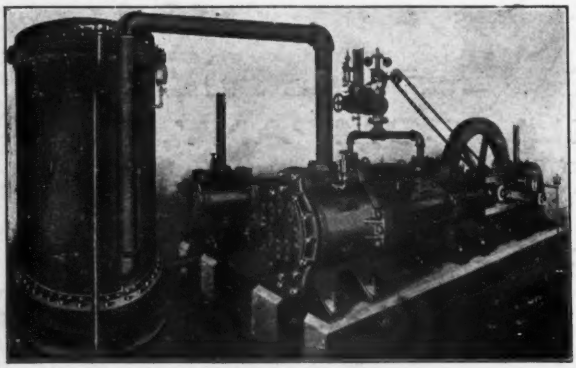

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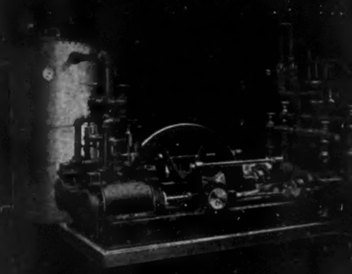

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